REPORT

OF THE

COMMITTEE ON DRAINAGE:

Calcutta.

1857.

To

THE SECRETARY TO THE GOVERNMENT OF BENGAL.

SIR,

THE Committee, formed of the Members as per margin, convened under Orders No. 925, dated 29th March 1856, of The Honourable The Lieutenant-Governor of Bengal, for the purpose of investigating the Scheme and inquiring into the Report on the Drainage of Calcutta, drawn up and submitted to the Municipal Commissioners of this Town by their Secretary, Mr. Clark, Civil Engineer, are now enabled to lay before His Honor the result of their examination and scrutiny, with the hope that their labours (which have been necessarily protracted over a period of twelve months, owing to the time of each Member being much engrossed in his own special avocation) may conduce to the early amelioration of the present state of the Drainage and Water Supply of Calcutta, and to the health and well being of its inhabitants.

Mr. David Cowie, President, Chamber of Commerce.
Mr. G. Turnbull, F. R. A. S. Chief Engineer, East India Railway.
Mr. A. T. T. Peterson, Barrister-at-Law.
Captain C. B. Young, Engineers, Civil Architect, Calcutta.
Lieutenant de Bourbel, Engineers, Assistant to Chief Engineer, Lower Provinces, *Secretary.*

2. The Committee, in the course of their inquiry, have personally inspected the present Drainage of the Town; they have visited the Circular Canal, the Salt Water Lake, and its Channels; and have been in communication with Mr. Clark, C. E.; Mr. Rowe, the Surveyor to the Conservancy Department; Mr. Galiffe, the Collector of Tolls on the Canals;

Mr. Rose, the Superintendent of Suburban Roads; Captain Howe, Secretary to the Officiating Superintendent of Marine; and with others; to all of whom the Committee are much indebted for the readiness and courtesy with which they have rendered assistance and imparted valuable information.

3. The Members have taken into consideration the Reports of the various Engineers who have already recorded their opinions on the Drainage of this Town; they have borne in mind the recommendations of the Fever Hospital Committee; have perused attentively the Reports on the Drainage or Water Supply of Bombay, Madras, New York, and other Cities; and have studied the systems adopted in some European Towns; especially the views recently set forth to the London Metropolitan Commission of Sewers by their Engineers, Messrs. Bazalgette and Hayward, and by others; and the Reports thereon, prepared by Messrs. Cubitt and Stephenson, the Consulting Engineers.

4. The evidence which it has been necessary to take, and some of the data and information on which the Committee have based their opinions, will be found appended to this Report, which gives expression to their views on the principal features of Mr. Clark's project, and to their recommendation of the proper system and course to be adopted for the improvement of the Drainage of this Capital.

5. In presenting this Report, the Committee would observe that, if any inaccuracies in detail be found to exist, they have necessarily arisen from the want of more minute and extended information. The general principles laid down, however, they confidently believe to be correct.

Section E.

On the General Outline of Mr. Clark's Scheme.

Levels.

6. The Committee have verified Mr. Simms' levels of Calcutta, (taken to the datum zero of the sill of Kidderpore old Dock,) as far as they are connected with Mr. Clark's project, and consider them correct and sufficient to frame thereon a general

system for the drainage of this City; but for any practical development thereof, it will be necessary first to obtain a series of very accurate levels of the surface of the Town, and careful observations of the tides, both in the Hooghly and Salt Water Lake.

Drainage.

7. The arterial drainage of Calcutta, *viz.* the receiving sewers, mains, and collateral street drains, only, are provided for in the Scheme under review; the branch, or minor drains, which are to connect houses and premises with the former, will have to follow, and are not included in the Estimate, it being proposed to make it compulsory on proprietors to carry them out. This arrangement the Committee approve, and recommend that the requisite powers be delegated to the Municipal Commissioners, to enable them to enforce this Clause.

Into the Hooghly.

8. To drain Calcutta into the River Hooghly is not advisable, as such a system would be intermittent owing to the rise of the tides, and the noxious effluvium from the sewerage would create mortality among the Shipping of the Port.* As the same objection applies to Tolly's Nullah and to the Circular Canal, the Committee coincide in Mr. Clark's opinion, that the drainage of this City should fall into the Salt Water Lake, which is in the direction of the natural declivity of the ground.

Into the Salt Water Lake.

Plan.

9. They adopt the general alignment and plan of the system of sewers, with inlets, for natural flushing from the Hooghly River, as laid down in the project; the whole converging to a point near Entally, beyond the end of Durrumtollah; and they approve of the out-fall selected by Mr. Clark, *viz.* for the sewage into the Tengrah Creek of the Salt Water Lake, and for the storm-waters into the Baliaghatta Cut and Circular Canal.

Lift.

10. To maintain a constant out-run at Entally, it is indispensable that the sewage be pumped up there: the steam power hereinafter mentioned for this purpose will lift it into a sewer extending thence to Tengrah Creek, near the mouth of which, reservoirs, with gates opening outwards into the deep water channel, should be provided for the retention of the sewage during flood, and until it can be released at the ebb of tide to flow out into the main channel of the Salt Water Lake, the capacity and tidal power of which the Committee consider sufficient to ensure the final removal of the City Drainage to the Sea.

Out-fall.

---

* *Vide* page lxix. of Evidence, Appendix V.

11. If hereafter this channel should be enlarged, and docks added for the vessels engaged in the water communication between Calcutta and the Mutlah, it may become necessary to excavate a direct cut through the Southern portion of the Salt Water Lake, to pass off the sewage from Tengrah into one of the Creeks of the Mutlah River, connecting at the same time the head of such cut with the Circular Canal near Dhappa, in order to obtain a flush for scour when requisite.

Portions of City not included.

12. Mr. Clark's Plan and Estimates do not include the drainage of Coolie Bazar, the Fort, the Maidan, or any of the parts of the Town outside the Circular Road. That part of the City which is outside the Circular Road, and all future extensions in that direction, which do not enter into his Scheme, may have the advantage of the present intercepting sewers as far as their sewage is concerned; but the drainage of the rain-fall upon them is not provided for, nor are any mains or other drains for them included in his Estimate.

Section II.

Rain-fall.

13. The Committee approve of Mr. Clark's calculation of the quantity of rain-fall, for which it is necessary to provide sufficient capacity in the receiving sewers, *viz.* ¼ of an inch per hour, or 6 inches in 24 hours. Although extraordinary cases may occur, when the rain-fall exceeds this limit, they believe that, with the precautions noted below, no serious or lasting inconvenience need at such times be apprehended.

Storm Outlets.

14. Mr. Clark has supplied one outlet for storm water at Manicktollah into the Circular Canal, and another into the Baliaghatta Cut from Entally, but also intends that his receiving sewers shall discharge storm-waters at both ends. The North and South, or Nimtollah and Tolly's Nullah, sewers of his project, are level for a considerable distance at each of their extremities. These may act as he anticipates, *viz.* by discharging at the upper, as well as at the lower end, but the discharge at the former will be very feeble until the other outlet is blocked up, and flooding in consequence will ensue thence, unless the crown of the sewer be very much below the surface of the soil.

15. As the tide ranges in the River during the rains from 9 and 10 to about 21 feet above datum, the time during which it would be below the mouth of a sewer placed at 12 feet above datum would be but short, and the efficiency of the river ends of the sewers as vents for storm-waters would be likely to be considerably impeded. In order, therefore, to avoid the unpleasant consequences of backing up the mains and collateral street drains, and flooding the lower parts of the City, additional outlets for storm-water must be provided, both into the Circular Canal from the Upper Circular Road sewer, and into the Salt Water Lake from the Lower Circular Road sewer.

Section III.

Salt Water Lake.

Surface level.

16. Levels of the Salt Water Lake, and observations of the tides of its deep water channel, into which all the Lake waters drain, have been taken by the Committee at Dhappa, at the junction of the Tengrah Creek, 1 mile Eastwards, and at Bamunghatta, 4 miles further down the stream. These differ from those assumed by Mr. Clark from previous records. The general level seems to have risen since former observations were made. The levels now are—

Highest level in the rains, 12·56 feet above datum.

Lowest in the dry season, 6·78 feet ditto.

The levels formerly were—

Highest level in the rains, 10 feet 2 inches above datum.

Lowest ditto in dry season, 7 feet ditto.

17. This elevation of the surface of the Lake may be ascribed to the gradual restriction of its area by the proprietors yearly reclaiming and bringing under cultivation the land along its borders. In order to prevent a further rise of the waters, the Committee consider that it would be a wise measure to give to the Municipal Commissioners of Calcutta a general jurisdiction over, and powers as Conservators of, the Salt Water Lake and its channels, with a view to maintain it as an efficient out-fall for the drainage of the City.

11. If hereafter this channel should be enlarged, and docks added for the vessels engaged in the water communication between Calcutta and the Mutlah, it may become necessary to excavate a direct cut through the Southern portion of the Salt Water Lake, to pass off the sewage from Tengrah into one of the Creeks of the Mutlah River, connecting at the same time the head of such cut with the Circular Canal near Dhappa, in order to obtain a flush for scour when requisite.

Portions of City not included.

12. Mr. Clark's Plan and Estimates do not include the drainage of Coolie Bazar, the Fort, the Maidan, or any of the parts of the Town outside the Circular Road. That part of the City which is outside the Circular Road, and all future extensions in that direction, which do not enter into his Scheme, may have the advantage of the present intercepting sewers as far as their sewage is concerned; but the drainage of the rain-fall upon them is not provided for, nor are any mains or other drains for them included in his Estimate.

Section II.

Rain-fall.

13. The Committee approve of Mr. Clark's calculation of the quantity of rain-fall, for which it is necessary to provide sufficient capacity in the receiving sewers, *viz.* $\frac{1}{4}$ of an inch per hour, or 6 inches in 24 hours. Although extraordinary cases may occur, when the rain-fall exceeds this limit, they believe that, with the precautions noted below, no serious or lasting inconvenience need at such times be apprehended.

Storm Outlets.

14. Mr. Clark has supplied one outlet for storm water at Manicktollah into the Circular Canal, and another into the Baliaghatta Cut from Entally, but also intends that his receiving sewers shall discharge storm-waters at both ends. The North and South, or Nimtollah and Tolly's Nullah, sewers of his project, are level for a considerable distance at each of their extremities. These may act as he anticipates, *viz.* by discharging at the upper, as well as at the lower end, but the discharge at the former will be very feeble until the other outlet is blocked up, and flooding in consequence will ensue thence, unless the crown of the sewer be very much below the surface of the soil.

15. As the tide ranges in the River during the rains from 9 and 10 to about 21 feet above datum, the time during which it would be below the mouth of a sewer placed at 12 feet above datum would be but short, and the efficiency of the river ends of the sewers as vents for storm-waters would be likely to be considerably impeded. In order, therefore, to avoid the unpleasant consequences of backing up the mains and collateral street drains, and flooding the lower parts of the City, additional outlets for storm-water must be provided, both into the Circular Canal from the Upper Circular Road sewer, and into the Salt Water Lake from the Lower Circular Road sewer.

Section III.

Salt Water Lake.

16. Levels of the Salt Water Lake, and observations of the tides of its deep water channel, into which all the Lake waters drain, have been taken by the Committee at Dhappa, at the junction of the Tengrah Creek, 1 mile Eastwards, and at Bamunghatta, 4 miles further down the stream. These differ from those assumed by Mr. Clark from previous records. The general level seems to have risen since former observations were made. The levels now are—

Surface level.

Highest level in the rains, 12·56 feet above datum.

Lowest in the dry season, 6·78 feet ditto.

The levels formerly were—

Highest level in the rains, 10 feet 2 inches above datum.

Lowest ditto in dry season, 7 feet ditto.

17. This elevation of the surface of the Lake may be ascribed to the gradual restriction of its area by the proprietors yearly reclaiming and bringing under cultivation the land along its borders. In order to prevent a further rise of the waters, the Committee consider that it would be a wise measure to give to the Municipal Commissioners of Calcutta a general jurisdiction over, and powers as Conservators of, the Salt Water Lake and its channels, with a view to maintain it as an efficient out-fall for the drainage of the City.

18. The readings on the Gauge at Dhappa Dock (the junction point of the Circular Canal with the main channel of the Salt Water Lake and 2½ miles East of Entally) give the following results :—

1856.	April 17th to May 20th .	Mean High water	..	11·58	feet above datum ..	Dry season.
	Do. do.	,, Low water	..	7 92	,, do. do. ..	
	July 17th to October 24th	,, High water	..	12·05	,, do. do. ..	Rainy season.
	Do. do.	,, Low water	..	11·07	,, do. do. ..	

Section IV.

Detailed View of the Main Arteries of the System

19. The salient feature of this project is to drain the greater portion of Calcutta into principal receiving sewers, which, crossing the city from West to East, fall into a large intercepting sewer laid along the Circular Road, and converge to Entally.

Position.

20. The Committee think the position of the Circular Road, Durrumtollah and Colootollah, main arteries to be well chosen, and consider that the area of the Town, North of the latter should be as nearly as possible equally divided between two other transverse receiving sewers.

Extension of Streets.

21. In carrying this plan into effect, some difficulty may be found in constructing these large deep sewers through certain streets of this City, which are extremely narrow, irregular, and winding; but Mr. Clark has anticipated this objection by the suggestion, that wherever such obstacles are met with, the sewer should become the pioneer of a new street. The Committee are satisfied, that this measure is essential, not only to the proper drainage of this Town, but also for the improvement of these inconvenient public thoroughfares. They are aware of the very great expense to be incurred thereby, and therefore limit their recommendation to the reformation of such streets alone as will prove of immediate and undeniable benefit to the Public of Calcutta.

The following in their opinion will have thus either to be opened out or remodelled :—

	Length.
From Nimtollah Street Eastward to Circular Road ...	$\frac{10}{12}$ mile.
From Jackson's Ghaut to end of Moorgyhatta Lane ...	$\frac{6}{12}$ ditto.
Total ...	1⅓ miles.

The remainder of the streets, in which the main arteries are to be laid, *viz.* Colootolah and Mirzapore Street, Durrumtollah and the Circular Road, are of considerable width, and present no impediment of the above nature to the insertion of the principal sewers.

Occupation of land.

22. In all cases where the receiving or other drains will have to pass through private property, and it becomes necessary to occupy the land during the period of construction, the Municipal Commissioners should be empowered by law for this purpose, and a full right of access to the sewer be retained after completion.

New receiving sewer.

23. The Committee observe, that it is still proposed by Mr. Clark to drain the most Northern parts of the City into the Hooghly. They deem this objectionable, and recommend, in lieu thereof, the construction of another receiving sewer, commencing from the River and passing Eastward, through the centre of that portion of the Town, into the Circular Road intercepting sewer, with an outlet for storm-water at Ooltadangah into the Canal.

Nimtollah.

24. The Nimtollah sewer begins from the River margin, with its invert at 13 feet above datum, and ends at Entally at 9. It is on a dead level for about ½ a mile at its commencement and for ¾ of a mile at its Entally end. The whole fall, in a distance of 3¼ miles, is from 13 to 9 = 4 feet, or a mean of 1·2 feet per mile.

Colootollah.

The next receiving sewer commences from the River bank at 12 feet above datum and ends at Entally at 9. It passes down one of the principal City thoroughfares, Moorgyhatta and Colootollah Street. The first portion, running West to East, has an inclination of 12 to 9 = 3 feet in a distance of 1½ miles. It then falls into the before-mentioned level portion of the Nimtollah sewer, ¾ of a mile in length. Its mean fall, from end to end, is therefore 12 to 9 = 3 feet in 2¼ miles, or 1·3 feet per mile.

Durrumtollah.

The next receiving sewer passes directly from West to East down Durrumtollah, from Chandpaul Ghât, to Entally, commencing at 12 feet, and ending at 9 feet above datum. It is on a dead level for ¼ of a mile at its Eastern end—its mean fall throughout is 3 feet in 1¾ miles, or 1·7 feet per mile.

The last receiving sewer commences at Tolly's Nullah, near Zeerut Bridge, at 12 feet above datum, ending at Entally at 9. For the first $\frac{3}{4}$ mile of its course, it is perfectly level; for the next $1\frac{1}{2}$ miles, it has a fall of 3 feet; and for the remaining $\frac{3}{4}$ mile, it is again level. Its mean fall throughout, therefore, is 12 to 9 = 3 feet in 3 miles, or 1 foot per mile.

Tolly's Nullah.

25. Thus all the receiving sewers of Mr. Clark's Scheme have portions, which are on a dead level. The Nimtollah and Tolly's Nullah ones have, respectively, $\frac{1}{2}$ and $\frac{3}{4}$ of a mile at their commencement, and all the converging sewers at the Entally end are flat for an aggregate of $1\frac{3}{4}$ miles. The total length, therefore, of sewers on a dead level is 3 miles, and each receiving sewer has a mean fall throughout of considerably less than 2 feet per mile. This the Committee do not approve, as even within the aid of the flush from the River Hooghly, it will not be sufficient to produce the requisite velocity for scour in the dry months of the year; but, under the arrangements they propose hereinafter for an increased lift at Entally, this small amount of fall will be obviated.

Section V.

Level of the Inlets and Rise of Tides in the Hooghly River.

26. The level of the inlets of the receiving sewers from the River and Tolly's Nullah is fixed by Mr. Clark at 12 feet above datum for three of them, and 13 feet for the Nimtollah one, "which mark," he writes, "during the month of "April, was covered to a depth varying from 1 foot to 2 feet 10 inches "by seventeen tides."

Level of Inlets.

"This latter quantity of water, with the inclination of the sewer," Mr. Clark continues, "will give a velocity of 2·3 feet per second," and will, he considers, "be sufficient, with proper attention, even at that dry season "of the year, to keep that sewer clean."

27. From the registered observations of the height of the river tides kept during the years 1855 and 1856, in the Dock Yard, by the Marine Superintendent, it appears

Range of tides.

that the following number of tides rose up to and above 13 feet, and the other heights given in the Table, during the months named, of the dry and rainy seasons of these years :—

Number of Tides.

Years	Seasons.	Months.	Height of the Gauge, Kyd's Dock.								
			13ft.	14.	15.	16.	17.	18.	19.	20.	21ft.
1855.	Dry Months.	November ...	38	28	18	8	...	...	...	...	...
		December ...	24	14	6	..	...	...	...	...	...
		January ...	19	8	3	..	...	...	...	...	...
		February ...	24	16	8	5	...	...	...	...	...
		March ...	31	17	8	4	...	...	...	...	...
		April ...	36	29	23	8	...	...	...	...	...
		May ...	44	38	25	13	6	...	...	...	...
	Rainy Season.	June ...	52	37	25	15	8	4	...	...	...
		July ...	60	57	52	43	30	14	8	6	1
		August ...	60	60	60	60	50	43	35	28	10
		September ...	58	58	51	48	42	39	34	22	14
		October ...	57	52	44	37	29	17	...	...	..
1856	Dry Months.	November ...	45	33	25	16	8	3	...	...	..
		December ...	30	18	10	4	...	..	...	...	..
		January ...	21	15	5	1	...	..	...	...	..
		February ...	27	14	7	3	...	..	...	...	..
		March ...	34	29	21	10	5	..	...	...	..
		April ...	36	32	25	21	9	3	...	...	.
		May ...	43	33	21	13	8	2	...	...	..
	Rainy Season.	June ...	52	46	37	23	10	...	...	...	...
		July ...	60	60	53	48	37	24	16	8	2
		August ...	60	59	59	56	50	43	39	32	17
		September ...	58	58	58	56	51	45	37	29	17
		October ...	60	57	55	48	46	36	25	19	14

28. It appears, therefore, that such drains as have their River inlets placed at 12 or 13 feet above datum will receive plenty of water from April to November of each year; it is during the remaining four months, *viz.* December, January, February, and March, that the supply is limited, and the Committee now turn to the consideration of its degree of power, to cleanse the receiving sewers.

Flushing.

Section VII.

Velocities of Fluid in Receiving Sewers.

29. When drains have a considerable fall, and the sewage in them is fully diluted, the velocity of motion sufficient to keep all solid particles in suspension, and to prevent deposit, is $2\frac{1}{2}$ feet per second, which is correctly stated by Mr. Clark to be the minimum velocity requisite to produce self-cleansing action in a sewer.

30. But where the amount of fall is limited, the sewers cannot always be kept clean, and deposit is unavoidable: it then becomes necessary to have recourse to a flush, in order to scour them out occasionally, and the velocity requisite to effect this action is from $3\frac{1}{2}$ to 4 feet per second.

31. By Eytelwein's formula for ascertaining the velocities of water, it requires a discharge of 56·9 cubic feet per second, to create, in a 7-feet circular drain, having an inclination throughout of 2 feet per mile, a continued velocity of $2\frac{1}{2}$ feet per second, depth being 4 feet; but when running full to the crown, a natural velocity of 3·37 feet per second only can with safety be attained.

$V = \frac{9}{10}\sqrt{2\ f.\ d.}$ Where f. is the fall in feet per mile and *d.* is the hydraulic mean depth.

$$f = 2 \text{ and } d = \frac{\text{area}}{\text{perimeter}} = \frac{22{\cdot}76}{12} = 1{\cdot}89$$

$$V = \frac{9}{10}\sqrt{2 \times 2 \times 1{\cdot}89}$$

$= 2{\cdot}47$ feet per second.

Discharge = area × velocity.

$= 22{\cdot}76 \times 2{\cdot}5$

$= 56{\cdot}9$ cubic feet per second.

32. It is obvious therefore, that as a sewer of the above size and fall cannot, under ordinary circumstances, obtain the velocity due to scour, it must depend chiefly for its efficient action upon such a regular supply of fluid as shall maintain in it a self-cleansing velocity.

33. The amount of drainage per head of the population may be assumed at 30 gallons per diem (in the latest London Reports it is fixed at $31\frac{1}{4}$ gallons per head per diem), and of this about one-fifth is considered due to sewage strictly, the remainder to the water supply thrown into the Town.

If therefore 5 cubic feet, which are equal to $31\frac{1}{5}$ gallons, be allowed as the amount of drainage per head per diem proceeding from a full

water supply, and one-half of it or $2\frac{1}{2}$ cubic feet be supposed to flow off in the first six hours—if also the population be taken at 60,000 inhabitants per square mile,* the Colootollah receiving sewer, which drains the largest area of all the sewers, *viz.* $1\frac{1}{2}$ square miles, will, towards the middle of its course have an ordinary drainage discharge of 5·2 cubic feet per second. This quantity of fluid will, of itself, stand in the sewer at a depth of 12 inches nearly.

34. Supposing then, that a full water supply be given to this Town, as assumed in the foregoing calculation, in order to produce a cleansing action in the sewers during the dry months of the year, there would still be required (if the declivity of the receiving sewers is to remain at 2 feet per mile), in addition to the ordinary sewage flow of 5·2, a volume of 51·7 cubic feet per second, to obtain which from the River, in a 7-feet circular drain, a depth of $3\frac{3}{4}$ feet at the inlet is necessary.

56·9 — 5·2 = 51·7.

35. A reference to the Tables in Section V. will show, that this amount of water from the River would be but rarely obtained, during the months of December, January, and February, by such sewers as have their inlets laid at 12 and 13 feet above datum.

36. The Committee observe that great assistance would, no doubt, be derived by the judicious use, at intervals, in the sewers, of gates to head up the fluid, and from the occasional application of hand labour; but in order to keep them clean, they consider it absolutely necessary to increase the fall given by him to the large receiving sewers.

Section VII.

Entally Outlet-Lift and Extended Out-fall.

37. The converging point of outlet at Entally is assumed by Mr. Clark at 9 feet above datum, which is stated in his Report† to be the surface level of the water in the Lake during the dry season.

38. In case of an extended out-fall to Tengrah being considered necessary, he also made a provision to lift the entire amount of sewage at

* The area of Calcutta is 7·8 square miles, and the population, by the Census of 1850, is 450,000.

† *Vide* page 75 para. 12 of Mr. Clark's Report to the Municipal Commissioners; also subsequent memorandum by him dated 18th January 1856, at page 70 of Evidence, Appendix V., on the subject of the levels of the Salt Water Lake.

Entally a total height of 6 feet, leaving the level of the out-fall at Tengrah also 9 feet above datum.

39. The Committee find by the observations, survey, and levels taken under their direction, that the ordinary *low* water mark of the Salt Lake and the natural source of the Tengrah Creek are both about 9 feet above datum, and they therefore, under these circumstances, accept the depth fixed by Mr. Clark for the level of the invert of the extremity of the extended out-fall at Tengrah.

Level of out-fall.

40. From Tengrah to Entally, the distance is 2 miles, and if a mean inclination of 3½ feet per mile be given to this sewer, it would place the level of the invert of the extended out-fall at Entally at 16 feet above datum.

41. But in order to secure a sufficient fall to the whole system, the Committee are of opinion, that the level of the invert of the receiving sewers converging to the Entally outlet should be fixed at 5 feet above datum in lieu of 9 feet, as proposed by Mr. Clark.

Level of outlet.

This depth has been assumed by them (as will be apparent from the sequel) in order to obtain the utmost amount of flush from the River, consistent with a due rate of inclination to the sewers, and having regard also to the proper internal altitude of the converging sewers at the Entally outlet, the crown of which should be kept at a height sufficient to secure a head of water into the Baliaghutta Cut in case of necessity.

42. The difference between the points now fixed, *viz.* 5 and 16 feet above datum, will give a lift at Entally of 11 feet, or practically an average of 14 feet from the silt pit into the covered sewer of extended out-fall to Tengrah.

Lift.

43. The Committee have carefully weighed the greater difficulties of construction and the additional expense attendant upon this lowering at one extremity of the main arteries of Mr. Clark's system, but they conceive that the advantages to be derived therefrom of increased fall and a more perfect action of the sewers will fully warrant its adoption.

Section VIII.

Distribution of Fall proposed by the Committee.

44. If then we assume the level of invert of the converging point of all the receiving sewers at the Entally outlet to be fixed at 5 feet above datum and the invert levels of the River inlets of all the receiving sewers

to be kept at 12 or 13 feet above datum, the fall obtained in each will be as follows :—

Names of Receiving Sewers.	Length.	Level of Outlet above datum.	Level of Inlet above datum.	Fall in feet.	Mean inclination in feet per mile.
Northernmost or new Receiving Sewer ..	3½ mile	5 feet	13 feet	8	2·28
Nimtollah ..	3¼ ,,	ditto	13 ,,	8	2·4
Colootollah ..	2¼ ,,	ditto	12 ,,	7	3·11
Durrumtollah ..	1¾ ,,	ditto	12 ,,	7	4
Tolly's Nullah ..	3 ,,	ditto	12·5 ,,	7½	2·75
Total ...	13¾ ,,			37½	2·72

45. The falls thus allotted to the sewers might also be distributed along their several lengths in this manner :—

Names of Sewers.	Total fall allotted.	Fall from Inlet at 4 feet per mile.		Fall at 3 feet per mile.		Fall at 2 feet per mile to Outlet.		Total Length.	Area drained.
New Receiving Sewer	8	2 ft.	½ m.	0 ft.	0 m.	6 ft.	3 m.	3½m.	½ sq. m.
Nimtollah ..	8	1 ,,	¼ ,,	3 ,,	1 ,,	4 ,,	2 ,,	3¼	1⅙ ,,
Colootollah ...	7	4 ,,	1 ,,	1½ ,,	½ ,,	1½ ,,	¾ ,,	2¼	1⅙ ,,
Durrumtollah .	7	7 ,,	1¾ ,,	0 ,,	0 ,,	0 ,,	0 ,,	1¾	1⅙ ,,
Tolly's Nullah...	7·5	2 ,,	½ ,,	1·5 ,,	½ ,,	4 ,,	2 ,,	3	1¼ ,,

Fall of main arteries.

46. By this arrangement, the portions of the receiving sewers crossing the City from West to East, will have slopes of 4 and 3 feet per mile, while the rest of their lengths or the intercepting sewer in the Circular Road will be laid at 2 feet per mile.

47. At the former mean inclination, the quantity of fluid necessary to maintain, in a 7-feet circular drain, a velocity of 2½ feet per second is 22·65 cubic feet per second, depth being 2 feet ; and the head of water required for a velocity of 3½ feet per second is 5 feet.

$$f = 3{\cdot}5 \text{ and } d = \frac{\text{area}}{\text{perimeter}} = \frac{9{\cdot}06}{7{\cdot}8} = 1{\cdot}15 \text{ feet.}$$

$$V = \tfrac{9}{10}\sqrt{2 \times 3{\cdot}5 \times 1{\cdot}15}$$
$$= 2{\cdot}55 \text{ feet per second.}$$

$$\text{Discharge} = 9{\cdot}06 \times 2{\cdot}5$$
$$= 22{\cdot}65 \text{ cubic feet per second.}$$

$$\text{Again } f = 3{\cdot}5 \text{ and } d = \frac{\text{area}}{\text{perimeter}} = \frac{29{\cdot}4}{14{\cdot}1} = 2{\cdot}08 \text{ feet.}$$

$$V = \tfrac{9}{10}\sqrt{2 \times 3{\cdot}5 \times 2{\cdot}08} = 3{\cdot}43 \text{ feet per second.}$$

48. If 5 cubic feet or 30⅛ gallons be taken as the drainage per head per diem, the ordinary discharge resulting therefrom, half way down the

cross receiving sewer of 5·2 cubic feet per second, will stand in the sewer at a depth of 11 inches, with a velocity of 1·8 feet per second, nearly.

49. The additional volume requisite to produce cleansing action will be 17·45 cubic feet per second, and to obtain this from the River, a depth of 21 inches of water at the inlet is necessary.

22·65 — 5·2 = 17·45.

50. A reference to the Tables in Section V. will show, therefore, that the cross receiving sewers, with the above fall and size, whose inlets are laid at 12 and 13 feet above datum, will have this amount of aid from the River frequently during the dry season: they can also receive a flushing scour at intervals throughout the year, except perhaps in the months of December, January, and February.

River flush.

51. With regard to the intercepting sewer, the Committee think that, with the large quantity of concentrated sewerage, which it will at all times contain, the fall allowed of 2 feet per mile will prove sufficient.

52. The Committee wish to note that the above calculations and likewise those in Section VI. are based upon the average of the several data given; the deductions thus drawn represent only an average condition of things, and the velocities in the sewers therefore will vary accordingly, as the circumstances of fall of surface, depth and quantity of fluid therein become more or less favourable.

53. In addition to this, artificial means of flushing may at times be resorted to, for the purpose of a thorough scour, though the Committee do not apprehend that any necessity for the frequent application of the same will arise; but it is obvious, from the foregoing, that a diffused water supply over the City is an indispensable adjunct to its efficient drainage.

Artificial flush.

Section IX.

Silt Pits, Tengrah Creek, and Reservoirs.

54. The silt pits and pumping reservoirs connected with them at the converging point of outlet are necessary; and the Committee approve of their being placed near

Position.

Entally, but would prefer a site, at some distance East ward of the Circular Road, on the North side of the branch Canal where the ground is more open, less crowded with houses and premises, and not so valuable as on the South bank.

They and the opening into the Tengrah extended out-fall, should be well covered in and ventilated, so as to preclude annoyance to the neighbourhood. With proper precaution, the Committee think, no apprehension, need be entertained on this point.

55. An outlet for the surplus storm-water at the Entally end, opening from the silt pits into the Baliaghatta Cut, is requisite, as the Engine there could not pump it all off by the Tengrah extended out-fall. Double lock gates should be provided, one pair opening inwards to prevent the sewage from escaping into the branch canal, and another opening outwards to exclude the canal water from the silt pits and to let off the storm-water when necessary. The silt deposited in the receivers, would require to be removed in carts or boats as may be found most convenient in practice.

Extended Culvert.

56. The connecting sewer thence to Tengrah Creek should be covered over for the whole distance, as it will have to traverse a populous district; and the branch Canal should be filled in from its Western extremity down to the point where the above sewer will cross it. The soil for this purpose may be obtained from the excavation of the sewers and the silt receivers in that locality, and the Committee hope thus to put an end to the present Entally sink pit, which has for so long been a nuisance to its neighbourhood.

Reservoirs.

57. The sewage will flow through the connecting sewer and the Tengrah Creek into the reservoirs placed towards the mouth of the latter. It will there be pent up until at the ebb of tide, and on the opening of the gates, it can be released and discharged into the deep water channel of the Salt Water Lake.

Each reservoir should be large enough to hold at least the amount of sewage which is likely to be passed off from the Town during 12 hours.

Tengrah Creek.

58. The Committee, on inspection, find that the land about Tengrah is low, flooded at high water, and of some value for its fisheries. At the head of the Creek, there is a private mart, to which boats convey fire-wood and shells for lime from the Sunderbunds.

The Khal itself, which is of some size and depth, is fed by numerous small side streams which fall into it. To prevent therefore the sewage from spreading through these ramifications on to the surrounding ground, it will be necessary to enclose in the Creek, on both sides, from the extremity of the masonry sewer down to the reservoirs, so as to confine the fluid strictly within its limits.

Section X.

Water Supply, and Engine-power.

59. A full water supply being indispensable to the efficient drainage of Calcutta, the partial arrangements provided by Mr. Clark should be revised, with a view to an ample supply of the Hooghly River water after filtration to the City. Such alone, it is believed, could entirely remove the very great nuisance and annoyance now felt from the Public Tatties and the places of the Tolah Mehters. On this subject, and its intimate connection with drainage, with epidemic diseases, and the general sanitary state of the City, the Committee would beg to refer to the extracts and details given in the Appendix to this Report, under the head of Water Supply.

Amount of water.

Presuming the City to have an ample water supply, the amount used for all purposes, including tank and well water, also sewage proper, &c., may be taken at 31 $\frac{1}{6}$ gallons, or 5 cubic feet per diem. If one-half be supposed to pass off by the sewers in the first six hours of the day, and the population be taken at 60,000 to the square mile, the maximum discharge from the united receiving sewers at Entally for those parts of Calcutta included in the project would be 45 cubic feet per second, and to raise this amount of sewage

Steam Engine power.

an average lift of 14 feet, would require a 70-horse power engine. This must be provided in duplicate in case of accident.

60. It must also be recollected that more sewage than is included in Mr. Clark's scheme will be thrown into the intercepting sewer from those parts of the city which lie outside the Circular Road, when they are connected, as they must eventually be, with his system of sewers.

61. Apart from the foregoing is the consideration of the amount of water admitted into the receiving sewers from the River at the inlets for flushing, which, as it will inevitably be mixed up with sewage, cannot be let off into the canal; but there should be no difficulty in regulating this quantity, so as to adapt it to the capacity of the silt pits and the pumping power of the steam engines, which, as provided, the Committee believe to be ample for the purposes of lifting both sewage and flush combined.

Amount of flush.

Section II.

On the Minor Arrangements of Mr. Clark's Project.

62. The highest water in the Salt Water Lake being 12·56 feet above datum, the crowns of the sewers converging to Entally must be above this height, in order to secure a head of water in extreme cases, and the Committee would recommend 14 feet to be selected, which will give an internal altitude of 9 feet to the sewers at the outlet.

Chief public drains.

63. Double sluice gates should be provided at the River inlets of the receiving sewers, to act in the manner described by Mr. Clark.

64. To prevent any evil consequences from possible gorging of the sewers, chimneys, or openings, into the crowns of the arch, with valves and grated covers, should be supplied at suitable intervals near their lower extremities.

65. The capacity or size of the sewers, as detailed in the Tables appended to Mr. Clark's Report, will have to be somewhat altered under the preceding modifications to his system proposed by the Committee. They would especially refer to their rejection of the River ends of the receiving sewers as vents for storm-waters, the necessity of additional outlets for this purpose being provided into the Circular Canal and Salt Water Lake, the increased fall and the greater internal altitude given to the receiving sewers towards the point of convergence.

Size.

66. The outlets for storm-water should have the level of their inverts, at the point of connection with the principal sewer, placed above the ordinary surface of the sewage flow ; and be further provided with sluice gates, so as to retain a flush *ad libitum* in the receiving sewer when needed.

Side public drains.

67. The main sewers of Mr. Clark's Scheme, which fall into the large receiving sewers, would have generally the inclination stated of 5 to 6 feet per mile, and the collateral street drains also a fall generally exceeding 1 in 300.

New streets.

The Committee observe that on the large Map submitted by him several mains are designed apparently to run through new streets *viz.*

Continuation of Sobah Bazar Street	$\frac{1}{4}$ mile.
From River to Sukeas Street	1 mile.
Prolongation of Amherst Street North	$\frac{1}{6}$ mile.
Ditto ditto South	$\frac{1}{4}$ mile.
Total	$1\frac{2}{3}$ miles.

They highly approve of this proposed extension to the above thoroughfares, but remark that, as far as the requirements of drainage are concerned, it would be sufficient to occupy the ground temporarily during construction, retaining a full right of access to the sewers at all times after completion. They have therefore only entered a rough compensation in the Estimate for this purpose, and would leave it to the judgment and means of the Municipal Commissioners at the time of execution to determine whether the new streets shall be opened out for the improvement of this Town.

Present narrow streets.

68. The Committee would likewise draw attention to the difficulty of inserting the mains in a few of the very narrow streets of the City ; for instance in Cotton Street, average width 20 feet, Mr. Clark's Tables and Plan show that it is intended to excavate to a depth of 14 or 15 feet below the surface. This cannot be done without danger, and in such cases the levels of the mains must be revised ; but the general arrangement may be adopted.

The collateral street drains are not entered in the Plan or Tables appended to his Report, but this detail may be safely left for after consideration.

The curved junctions of side sewers should be effected with a drop-in, and this should be as great as practicable.

69. The Committee approve of the form of egg-shaped sewers, and concur in the propriety of making the large receiving sewers circular, so as to give them the greatest capacity, and keep the crowns under the surface of the ground, which in some parts of the City is at so low a level. Owing to the nature of the alluvial soil on which Calcutta is built, they advise, however, the base or foundation of the drain to be flattened; and wherever the subsoil is found to be loose and unstable during the construction of the large sewers, it will be necessary to build them with a platform below.

Form of public drains.

70. The dimensions given to the public sewers or drains generally are sufficient, but the masonry of the 8 and 7-feet sewers should not be less than 18 inches in thickness. The bricks should be radiating and moulded for the purpose, and the Committee cannot too strongly urge the necessity for accurate slopes and clean work being given to the sewers and drains.

Masonry.

71. During the course of their investigation, the Committee have had occasion frequently to dwell upon certain conditions of climate peculiar to the tropics, which differ very materially from the usual experience of Engineers in Europe, *viz.*, that hardly any rain is felt here for seven months, while during the rest of the year the amount of rain-fall is excessive; whereas in Europe it is more continuous and moderate throughout the year. This latter circumstance is of great importance to the efficient action of any system of drainage, and its loss in this country, during the dry season, has to be remedied by a more abundant water supply being provided, or by a means of flushing being added to the system.

72. Moreover, the Committee observe, that throughout this period the ordinary sewage discharge into the drains is but very small, compared with the drainage of the rain-fall into them during the wet season, and they therefore deemed it of utility to devise such a form of sewer as should accommodate itself to these widely varying conditions.

New design of sewer.

That which appeared to them the most suitable is shown in diagram No. I. of Appendix VII. where the circular shape is preserved to provide for the rain-fall; with the addition of a cunette at the bottom to carry off the sewage during the dry weather.

73. They find that a similar design has already been adopted in the latest sewers constructed in Paris, where however the chief object was to

afford facilities for cleansing out the drains when necessary, by giving a foot-path (elevated above the average surface of the fluid) for the men employed in this duty, and making use of the same as a platform for rails, whereon to move forwards a silt scraper and truck.

Gas and water-pipes are likewise placed within these sewers, supported by brackets let into the upper portion of the side masonry. This arrangement admits of the tubes being repaired without trouble when required, and obviates the great inconvenience of disturbing the public thoroughfares, which is unavoidable in other cities where such pipes are let into separate excavations along the streets.

74. As the attainment of all these objects is very desirable, and would also be of great benefit in Calcutta, the Committee recommend the form of sewer alluded to with confidence; the amount of water-way is not diminished therein; and with the same quantity of fluid, the velocity obtained would be somewhat greater than in the circular drain; while the depth of invert below the surface of the ground may remain the same.

The rails, trucks, and scrapers which may be employed in the removal of the deposit, should be of one uniform gauge, for the various dimensions of the larger sewers.

75. Mr. Clark's arrangements for ventilation, traps, passing off surface drainage, for collecting silt and road washings in cess pits, for providing traps to them, and gully grids, appear judicious.

Surface Channels.

76. Whenever the width of the street admits of it, the surface channels may be outside the foot-paths, as proposed by Mr. Clark. Such an arrangement would, however, require a change in the existing shades over doors and their extension over the road-way. If shades over head could be provided generally, they would conduce much to the general use of side foot-paths.

In the narrow streets, the surface channels or drains must be retained at the road-side close to the houses.

77. Sub-soil drainage of the City will doubtless be aided, if passage be provided for it into the sewers.

Utilizing sewage.

78. Although the process of converting sewage into deodorized manure has been much improved of late years and shown to be practicable and inoffensive, the Committee cannot entertain the hope of the time having yet arrived, when such process could be adopted in India with success, or its results brought generally into use, and profit derived from the sale of them. Should it,

at any future time, be deemed desirable to try the experiment, there will be no obstacle, as far as the works are concerned, to its being carried out.

79. The surplus water, which, during the time of heavy storms, would flow off by the Entally and other storm outlets into the Circular Canal, would be to so small an extent, if at all contaminated with sewage, as not to cause any objection to its being so discharged.

Scope of arterial drainage.

80. Although, generally, Mr. Clark's Scheme will place all parts of the City of Calcutta included by it within about 1,000 feet of a means of public drainage, as stated by him, yet, in some of the larger blocks of the City, the distance will be exceeded, and when the tortuousness of the lanes and of the boundaries of properties is taken into consideration, it is likely to be so in many more instances.

Side private drains.

81. The branch or private drains should have generally a fall exceeding 1 in 100 ; wherever this inclination can be obtained, the 6-inch drain pipes will answer, and the Committee concur in the recommendation of glazed pottery tubes for all dwellings, situated at the sides of streets ; large compounds and enclosures would require larger, but covered-in, drains, as mentioned by Mr. Clark.

House draining.

82. The Committee notice that Mr. Clark has not entered into detail on the subject of compulsory house draining—the very element of any system of Town drainage. They believe that no serious difficulty of construction is likely to arise in the connection of houses with public sewers, but that the habits of the native part of the population of Calcutta may interfere to some extent with the application and proper employment of the branch or private drains for this purpose. An ample use of water would rectify this inconvenience, but they also apprehend that the small means of the poorer classes will render them slow to avail themselves of the amount of water requisite to ensure cleanliness in this respect.

83. Unless the sources of the sewerage, or the centres of the block or squares of houses, are provided with plenty of water, the branch drains would not be able to carry off the filth into the public sewers, and where, from such cause, nuisance is likely to occur, the Committee advocate the entrance of the sewage into the public drains by suitable trap openings being made into them for this purpose, and that such points of reception should be constantly flushed by a stream of water from some

neighbouring public fountain or other source, whence water may be most readily obtained.

84. The present Drainage of this Town is not adverted to in Mr. Clark's Report, but the Committee concur in the after opinion expressed by him* that the existing drains should be preserved intact until the new system comes into operation, and that they may even for a time be adapted to it when intercepted by new sewers deeper than themselves; though as the whole must be remodelled eventually, no attention has been paid to them in drawing up the Estimate.

Present drainage.

Section XIII.

Summary of the Recommendations of the Committee.

85. It will be seen from the foregoing, that the Committee have adopted Mr. Clark's plan of drainage generally, with certain reservations and modifications; the chief points to be noted are as follows:—

I. That no part of Calcutta, with the exception of the Fort, the Maidan, and Coolie Bazar, should be drained into the Hooghly River, Tolly's Nullah, or Circular Canal; but that all the sewage of the City should be concentrated by its drains towards Entally, the central point of its Eastern boundary, and be there pumped up by adequate engine power, to a height sufficient to ensure its discharge, 2 miles off, into the Tengrah branch of the main channel of the Salt Water Lakes whence it would flow off finally into one of the Creeks connected with the Bay of Bengal.

System.

II. One receiving sewer has been added, to the four already provided by Mr. Clark, in order to pass off the sewerage of the most Northern portions of the City into the Circular Road intercepting sewer.

New receiving sewer.

III. The inlets of the principal or receiving sewers are retained at the level fixed by Mr. Clark, in order to preserve

Level of inlets.

Vide page xii. of Evidence, Appendix V.

the advantage to be derived from the River flush as much as possible, and for the purpose of securing a good fall into them from the side public or private drains.

Flush.

IV. The inclination given by Mr. Clark to his receiving sewers not being deemed sufficient, the Committee have lowered the level of the point of outlet at Entally by 4 feet, thus increasing the fall considerably, which they have distributed so as to allow the receiving sewers, which cross the City from West to East, slopes of 4 and 3 feet per mile, while the remainder of their lengths, or the intercepting sewer in the Circular Road is laid at 2 feet per mile.

Level of outlet.

Fall.

V. As the increased fall thus given, and the high range of tides in the River during the rains, will interfere with the efficiency of the River mouths of these sewers as vents for storm waters, additional outlets have been provided for this purpose into the Circular Canal and Salt Water Lake.

Storm outlets.

VI. The average surface of the main channel of the Salt Water Lake is higher than the level assumed by Mr. Clark, and a greater internal altitude has, in consequence, been given to the receiving sewers at the point of convergence, to ensure a head of water in extreme cases into the Baliaghatta Cut of the Circular Canal.

Size of sewers at Entally.

VII. The Committee retain the extremity of the extended out-fall at Tengrah at the level fixed by Mr. Clark, but they have increased the inclination given by him to the connecting sewer thence to Entally, the whole length of which should be covered in—

Out-fall.

VIII. The height therefore to which the concentrated sewage at Entally must be lifted has been necessarily much augmented from the lowering of the main arteries of the system and from the elevation of the extended out-fall, and a corresponding steam engine power in duplicate has been provided to pump up both sewage and flush combined.

Lift.

IX. Reservoirs have been provided at the Tengrah Creek to receive the sewage, which, after being pumped up at Entally, will flow down the extended out-fall sewer connecting Entally with the Creek ; and thence it will, upon the ebb of tide, be released, so as to pass off into the deep water channel of the

Reservoirs.

Salt Water Lake. The distance of these reservoirs from the City, *viz.* 3 miles, will prevent there being any nuisance.

Form of sewers.

X. The form of construction given to the various sewers and drains by Mr. Clark has been preserved generally, the masonry of the larger ones only being somewhat increased, and the bases of all squared, so as to give them more solidity. The Committee have also suggested a new design of sewer, which appears to them to contain advantages especially suited to the conditions of this climate and country.

Water.

XI. They consider a copious and diffused water supply over the City to be absolutely essential to its efficient drainage.

XII. The removal of the heavier particles of the drainage, which have settled in the cess and silt pits, is necessary under any system. The Committee also believe, under the recommendations made by them of a full water supply and increased fall to the sewers, as well as of a new form of drain adopted to facilitate the cleansing of the sewer, that the inconvenience of this kind of work will be materially diminished. When the whole sewage is well diluted, and a pumping engine at work, lifting it as fast as it flows into the receivers at Entally, silt is not likely to be quickly deposited in them; but when this has accumulated to any extent it can be removed without perceptible nuisance from the structure which covers in the silt receivers. The latter should be built on a suitable site to the North side of the Branch Canal.

Silt receivers.

Tidal observations.

XIII. The Committee are desirous of recommending, as highly conducive to the eventual completion of the objects of this Report, as well as being of great scientific interest generally, the institution of a regular and complete series of observations of the rise of the tides, both in the River Hooghly and in the Salt Water Lake Channel at Dhappa, and also at Bamunghutta.

Not only should the greatest rise and fall be regularly and accurately observed and recorded the whole year round, but also four times in each lunar month, at the different quarters of the moon, one or more sets of hourly observations of the tidal rise and fall should be taken, so as to ascertain the true tidal curve; and hence the time during which the surface level remains above or below a certain point on the Gauge.

On this important point, there is at present no information to be obtained.

Levels.

XIV. Accurate levels of the surface of the Town should also be taken in connection with the above observations.

Details.

XV. Each principal line of sewer, with all its tributaries, collaterals, and branches, should be first laid down upon paper in full detail, with working drawings, &c., and the feasibility of the several parts in connection with the main features of the system be ascertained and approved, so as to provide for the thorough-drainage of the total area thus embraced, before final sanction is accorded to the work of construction.

Future requirements of the City provided for.

XVI. When that portion of the present Suburbs which lies outside of the Circular Road is brought within the Town jurisdiction, the drainage thereof will have to be undertaken and may be paid for out of the local funds which will be realized from the house assessment and other dues, &c. In anticipation of this event, the size of the intercepting sewer along the Circular Road should be made of capacity sufficient to provide also for the additional drainage which will thus hereafter have to flow into it.

Section XIII.

Powers to be given to the Municipal Commissioners.

86. Any comprehensive system of drainage, like the one above proposed, will necessarily, in some cases, interfere with private property. If any such scheme, therefore be adopted, the Committee would respectfully represent, that to render any system of drainage complete, powers similar to those conferred on Commissioners of Sewers in England, must be given, by local Legislative Enactment, to the persons who may have to carry out the proposed works: such powers must include not only the occupation of

private lands (premises and tenements), either permanently or for temporary purposes, during the execution of the necessary works, also the compulsory drainage of private property within the limits of Calcutta ; but likewise a control over private rights without such limits, when any such control is required for the efficient execution and maintenance of a general system of drainage.

Section XIV.

Estimate.

Rates.

87. The rates of construction given by Mr. Clark in his Estimate are in the Committee's opinion, too low according to present market prices.

Additions to drainage.

88. Moreover, in order to secure a greater inclination, the receiving sewers have been sunk lower at Entally, thus enlarging them at the outlet, causing deeper excavations, making pumping up the sewage a necessary condition of the system, creating a greater lift, and necessitating a larger amount of steam power in duplicate—additional expense will thereby be incurred.

Also, the new receiving sewer, the extra outlets for storm-water, the increased thickness proposed for the large sewers, the additional cut, lock and gates at Entally into the branch Canal, the further covering to the connecting sewer, clearing out the Tengrah Creek, and the open reservoirs with gates near the mouth—all will be in excess of the amount of Estimate.

Water supply.

The Estimate of water-works given by Mr. Clark is also considered inadequate for a diffused system of water supply over the Town, which is deemed so essential. The Committee would, however, observe, that the works for drainage, though defective without it, need not be delayed on this account, as some time must necessarily elapse before a proper system can be decided upon.

89. The following is an abstract of the probable cost of a thorough system for the drainage of this Capital, in the manner recommended by the Committee :—

Five Receiving Sewers, with Gates, Storm Outlets, and Cut, with Lock and Gates, at Entally	8,28,000
Main and collateral Street Drains	12,94,000
All Surface Channels, Man Holes, Cess Pits, Iron Pentstocks and Sluices, Ventilating Tubes, Flushing Gates, Gullies, &c.	8,06,000
Two Steam Engines, of 70 H. P. each, including buildings, Settling Receivers, &c., at £200 per horse power ..	2,80,000
Culvert from Entally to Tengrah, Clearing out Creek with Reservoirs, &c.	77,000
Grand Total, inclusive of Superintendence and Contingencies, Rupees	32,85,000

This Estimate is based on the supposition, that the material is to be prepared, and the construction executed, by the Establishment of the Municipal Commission, with time at disposal; but if the work is to be done expeditiously, and by contractors, the construction charges will be proportionately exceeded.

Work by contract.

91. For water supply only, a rough valuation is subjoined :—

If 20 gallons per head per diem be furnished to 450,000 inhabitants, it will amount to 9,000,000 gallons per day, —then 120 H. P. Engines, at £200 per H. P., including buildings, &c.	2,40,000
90 miles of piping, at £800 per mile, with filtering reservoirs, fountains, &c.	8,10,000
	10,50,000
10 per cent. Contingencies	1,05,000
	11,55,000
Add drainage	32,85,000
Total, Water Supply, and Drainage, Rupees ...	44,40,000

91. The above may be assumed as the cost of construction alone for a system of drainage and water supply combined for this Capital, exclusive of the expense of land and premises which may have to be occupied or taken up for this purpose.

Compensation for land.

In order to compute this, it would be necessary first to have detailed surveys, of the ground and tenements and a minute local enquiry instituted so as to determine, the best, cheapest and precise line of direction for the sewers to follow. An approximation only can at present be attained in the following manner :—

Ground where required.	Length in feet.	Breadth in feet.	Area in Beegahs.	Total.	Cost in Rupees.	Remarks.
Receiving Sewers.						
North ...	1,760	20	2·15	....	.....	
	2,640	40	7·34	....	.....	
Nimtollah ..	3,080	40	8·56	....	.....	
	1,320	20	1·84	....	.....	
Moorgyhatta ..	2,640	20	3 67	....	.....	
Main Sewers.						
Sobah Bazar ...	1,320	10	·92	....	.....	
River to Sukeas Street	3,080	40	8·56	....	.....	
	2,640	20	3·67	....	.....	
Amherst Street, North	880	40	2·45	....	.....	
Ditto South .	1,320	20	1·84	41·3	7,20,000	Inclusive of compensation for Buildings, &c.
Silt Receivers, Engine Sheds, Cut and Lock near Entally on North side of Branch Canal ...	.....	....	.....	10·	20,000	Ditto.
Extended Out-fall to Tengrah	2 miles.	40	29·34	....	18,000	Ditto.
Creek ..	1½ miles.	100	55·	....	22,000	Inclusive of compensation for Fisheries, &c.
Reservoirs ..	1,500	600	62·5	....	1,000	Ditto.
Water Supply ..	.....	.....	.....	10·	1,00,000	

92. The Committee do not consider that the price of the ground for the new streets should of necessity be wholly paid out of any fund set apart for drainage purposes. They have stated their opinion, that the extension of some of these thoroughfares is also essential to the convenience of the public at large, and they think therefore that a sum equivalent to the temporary occupation may be debited to the Drainage Fund, the remainder being of a permanent nature should devolve on the Municipal resources, which may be applied to the general improvement of the Town.

Cost of ground for new streets.

With regard to the quantity of land required for the silt receivers, &c., extended out-fall and reservoirs, the expense thereof should be charged to drainage, and the following sums will therefore have to be added to the foregoing Estimate, *viz* :—

Cost of land for drainage and water works.

Brought forward...	44,40,000
Temporary occupation of land and premises, say one-tenth of total cost	72,000
Ground for Silt Receivers, extended Out-fall and Reservoirs	61,000
Land for Water Supply	1,00,000
Grand Total, Company's Rupees	46,73,000

Section XV.

On the Ways and Means.

93. The Committee are of opinion, that the present house assessment of Calcutta should be raised from 6¼ to 10 per cent., the increase of ¾ per cent. to fall on the owners, the remaining 3 per cent. on occupiers.

94. As the Municipal Commission is not a corporate body, and has no power to raise loans on the security of its surplus income, to defray the cost of a system of drainage and water supply combined, for this Capital the responsibility of furnishing the means must, in the first instance devolve upon Government, who have the right of control over the Municipal Funds.

Loan by Government.

Re-payment.

Assuming the expenditure of Rupees 5,00,000 a year, so as to complete the whole project in nine years, and that the house assessment were raised as suggested to 10 per cent., the Committee recommend that Government should advance to the Municipal Commissioners the additional sums annually required, receiving re-payment by instalments, with interest, at the rate of 5 per cent. per annum.

Time.

95. The accompanying figured Estimate will show that, under such an arrangement, the entire sum borrowed would, with interest, be finally cleared off in twenty-four years from the commencement of the work, or in fifteen from its completion.

Adjustment.

The correct mode of adjusting these loans would, of course, be that an annual interest account, on payments and receipts, be kept between Government and the Municipal Commission, but the annexed Scheme sufficiently estimates the ultimate result in point of time :—

Scheme for Re-payment of a Loan of 45 Lakhs of Rupees, to be borrowed by annual instalments of 5 Lakhs, and charged with 5 per cent. interest per annum.

Present Municipal Resources		3,64,700 Rupees	*Vide* Municipal Commissioners' Report, page 63.
Add 6¼ per cent. on Rupees 5,64,800, probable amount by which the present House Assessment may be raised		35,300	
		4,00,000	
Present City Rental is Rupees 57,79,920—3¾ per cent. on this, less 16 per cent. for Collection, &c., is ..	1,82,068		
Add for increase of present House Assessment, 3¾ per cent., minus 16 per cent. on collection, &c., ..	17,792	1,99,860	Revenue derivable from increased taxation
		5,99,860, or say 6 lakhs Annual Income.	

Assuming the Conservancy Expenditure at Rupees 3,21,000.*

			Annual Income.	*Surplus.*	*Residue of Loan.*
First year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 5,00,000	...	25,000	3,46,000	2,54,000	2,46,000
Second year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 7,46,000	...	37,300	3,58,300	2,41,700	5,04,300
Third year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 10,04,300	...	50,215	3,71,215	2,28,785	7,75,515
Fourth year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 12,75,515	...	63,775	3,84,775	2,15,225	10,60,290
Fifth year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 15,60,290	...	78,014	3,99,014	2,00,986	13,59,304
Sixth year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 18,59,304	...	92,965	4,13,965	1,86,035	16,73,269
Seventh year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 21,73,269	...	1,08,663	4,29,663	1,70,337	20,02,932
Eighth year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 25,02,932	...	1,25,146	4,46,146	1,53,854	23,49,078
Ninth year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 28,49,078	...	1,42,453	4,63,453	1,36,547	27,12,531
Tenth year	...		6,00,000		
Expenditure	..	3,21,000			
Interest on 2,71,251	...	1,35,626	4,56,626	1,43,374	25,69,157
Eleventh year	...		6,00,000		
Expenditure	...	3,21,000			
Interest on 25,69,157	...	1,28,457	4,49,457	1,50,543	24,18,614

Vide Municipal Commissioner's Report, page 63, Appendix 5.

		Annual Income.	Surplus.	Residue of Loan.
Twelfth year ...		6,00,000		
Expenditure ..	3,21,000			
Interest on 24,18,614 ...	1,20,930	4,41,930	1,58,070	22,60,544
Thirteenth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 22,60,544 ...	1,13,027	4,34,027	1,65,973	20,94,571
Fourteenth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 20,94,571 ...	1,04,728	4,25,728	1,74,272	19,20,299
Fifteenth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 19,20,299 ...	96,014	4,17,014	1,82,986	17,37,313
Sixteenth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 17,37,313 ...	86,865	4,07,865	1,92,135	15,45,178
Seventeenth year ...		6,00,000		
Expenditure ..	3,21,000			
Interest on 15,45,178 ...	77,258	3,98,258	2,01,742	13,43,436
Eighteenth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 13,43,436 ...	67,171	3,88,171	2,11,829	11,31,607
Nineteenth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 11,31,607 ...	56,580	3,77,580	2,22,420	9,09,187
Twentieth year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 9,09,187 ...	45,459	3,66,459	2,33,541	6,75,646
Twenty-first year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 6,75,646 ...	33,782	3,54,782	2,45,218	4,30,428
Twenty-second year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 4,30,428 ...	21,521	3,42,521	2,57,479	1,72,949
Twenty-third year ...		6,00,000		
Expenditure ...	3,21,000			
Interest on 1,72,949 ...	8,647	3,29,647	2,70,353	

96. The Committee had concluded this section of their Report, when they observed that, by Act No. XXVIII. of 1856 passed on 26th December, the house assessment of Calcutta had been raised from 6¼ to 7½ per cent., with an additional tax of 2 per cent. for Lighting and a further tax on horses and conveyances.

97. To carry out the recommendations of this Report would consequently require a still higher assessment to be levied, but the Committee desire to record their opinion of the paramount claim and anterior right of a Town to its Drainage and Water in preference to Lighting, the former being vital and essential, and the latter only of secondary importance to the welfare of the inhabitants; and they consider therefore that no part of the municipal revenues should have been devoted to the purposes of lighting by gas, until the first wants of the Town had been duly provided for and satisfied.

98. Of the additional funds thus required, they think that,

Further resources.

I. A rate for watering the streets would be a legitimate source of income, and would recommend its being levied upon those persons who benefit by the process, in the manner recommended by the Municipal Commissioners.

II. As soon as Calcutta is provided with the supply of water herein contemplated, and the houses are connected with the public pipes; the occupiers thereof might be made to pay for their water, in proportion to the quantity they receive.

III. As the natural flow of a certain portion of the Drainage of this Town has been intercepted by the construction of the Circular Canal, the Committee fully concur in the opinion expressed by the late General Forbes.* That the Canal "(from which a large revenue is derived) "should be made to pay for such injury to or interference with the "Drainage, as it may be instrumental in occasioning." In consideration therefore of the increase of expense thus entailed upon a system of Drainage, some aid might fairly be granted out of such surplus fund, as may accrue to the State from the tolls levied on the Canal, after deducting therefrom the cost of the construction and maintenance of the bridges and necessary roads in its vicinity.

---

* *Vide* page 57, para. 10, Appendix III. of Municipal Commissioner's Report.

Section XVII.

EXECUTION.

99. The Committee have thus reviewed in detail the several parts of the Scheme for the drainage of Calcutta, submitted to the Municipal Commissioners by their Secretary, Mr. Clark, C. E. who has well earned the acknowledgments of the Government and of the Public for his labours and able Report on this subject, and have only to add generally that, with the modifications and alterations proposed by them to secure a greater fall to the system of sewers, and to render them more efficient in their action by the addition of a diffused water supply over the Town, they believe that they may confidently recommend it to The Honourable The Lieutenant-Governor for adoption, in order to effect the required improvement in the now very imperfect drainage of this Capital. The Estimate drawn out by them will show what expenditure, in their opinion, will suffice to this end ; and the financial arrangements by which this sum may, according to their judgment, be made available, have been set forth in the preceding Section of this Report.

As the re-payment of the money borrowed will be extended over a period of twenty-four years at least, a portion of the cost of these great and important works being thus made to fall upon those who will hereafter participate chiefly in the benefit to be derived from them, there will be no extraordinary pressure upon the present generation of inhabitants, and it is hoped that the wishes of His Honor, as expressed in his letter under reply, will thus be answered.

100. It will of course be highly desirable that the works for drainage and water supply should be carried out economically, as well as efficiently.

The Committee, therefore, advise, that the execution of the works should be entrusted to a competent Engineer and Staff, placed under the close and careful supervision of the Municipal Commissioners, aided by a Consulting Engineer.

It would also be desirable, that as much of the materials as possible should be prepared in the Government Brick Yards at Akra, and if it can be advantageously arranged, portions of the works may be executed by contract, in order to ensure greater expedition.

The construction of the deep sewers should be carried on during the dry season only.

The Committee recommend, at first, the construction of one of the receiving sewers, together with the whole of its collateral and minor branches, experimentally, selecting either the one down Durrumtollah or Colootollah, which traverse the City from West to East, for that purpose. If this operation is attended with satisfactory and successful results, the whole system may then be carried out as speedily as possible, on the principles herein advocated.

(Signed) DAVID COWIE.
,, GEORGE TURNBULL, F. R. A. S.
,, A. T. T. PETERSON.
,, C. B. YOUNG, *Captain, Engineers.*
,, R. DE BOURBEL, *Lieut., Engineers.*

Drainage Committee.

APPENDIX I.

CALCUTTA.

Site.

CALCUTTA, the Metropolis of British India, 88° 30′ East Longitude and 22° 35′ North Latitude, situated on the left bank of the Hooghly, is bounded on the West by this River, on the South by Tolly's Nullah, and on the North and East by the Circular Canal, as far down as Entally.

Thence the Canal branches off in an Easterly direction to the Main Channel, at Dhappa, of the Salt Lake, which is a large expanse of water, connected by numerous deep armlets or creeks with the Bay of Bengal.

This Lake, in extent about 18 square miles, lies to the East of Calcutta, its Western border being distant about 3 miles from the Circular Road, the confine of the City proper in that direction.

The Town itself is about 4½ miles in length from North to South, and averages 1½ miles in breadth; it presents an area of 7¾ square miles, with a population of 450,000 souls.

The levels of Calcutta have been taken at various periods by several persons, the datum generally assumed being zero of the River Tide Gauge at Kyd's old Dock.

The principal series on record are those taken by Prinsep, Blechynden, Schalch, Simms, and Abercrombie.

Mr. Clark, in his project for the Drainage of Calcutta, states that Mr. Simms's levels, so far as he has been enabled to check the same with other levels taken by Major Schalch, appear thoroughly to be relied upon, and are sufficient for the purpose of laying out a general system of Drainage for the Town; but in the event of the works proposed by him being undertaken, it would be necessary to institute a careful revision of the whole.

The Committee, on investigation and comparison of the levels taken by Mr. Simms with those of Majors Schalch and Abercrombie, found a discrepancy between the two series of about 18 inches—this may probably result from the latter having taken their datum on the sill of the new Dock at Kidderpore, which is about 1 foot 10 inches higher than the sill of the old Dock or Mr. Simms's datum.

In order to verify one set, the Committee availed themselves of the services of Mr. Frederick Burr, an Engineer in the employ of the East India Railway Company, who, under the direction of Mr. Turnbull, carefully took a line of levels from Kidderpore to Chandpal Ghaut, thence along Durrumtollah and the Balliaghatta Canal to Dhappa, at the entrance of the Main Channel in the Salt Lake; also, diverging from the head of the Balliaghatta Canal at Entally, he carried another line of levels by Tengrah, terminating at the junction of the Tengrah Creek with the Main Channel through the Salt Water Lake, about one mile below Dhappa.

After being checked by fly levels, and connected with some of the bench marks left by Mr. Simms, the following results were obtained :—

	Height above datum.
Floor of Government House paving of verandah in centre of South face	27·67
By check levels	27·64
According to Mr. Simms	27·39
Floor of Sacred Heart Church West end of paving	28·17
By check levels East end of ditto	27·97
According to Mr. Simms	27·79
Spike in S. E. wing wall of Tengrah Bridge	24·72
According to Mr. Clark	24·20
Top of coping of entrance to Dock opposite to Dhappa Toll House ...	14·03
According to Mr. Clark	13·38

Simms's levels adopted.

As far as the Town is concerned, the above observations have verified the levels taken by Mr. Simms, and the Committee have decided upon adopting his figures, and consider them to be sufficiently correct for the purpose of basing thereon their recommendation for a general system of Drainage for Calcutta; but they concur in the opinion expressed by Mr. Clark, that for the practical development of any system, a most careful and accurate revision of the whole series is absolutely necessary.

Water-shed of Calcutta.

The site of Calcutta may be described generally, as a level plain or flat. It has however its small inequalities.

The bank along the margin of the River Hooghly is the most elevated portion of Calcutta, varying from 23 feet above datum at its South to 26 and 27 feet at its North end, and one part, near the Mint, is as high as 30 feet above datum.

From this ridge, the surface of the ground forms an inclined plane with a mean declivity of 3 feet per mile towards the interior, where the general level of the rice cultivation is 10 or 11 feet above datum, down to the Salt Water Lake, or in a direction from West to East. The lowest part of Calcutta is in the North-east quarter about Machooa Bazar, where it is 18 feet above datum—this is 5 feet 4 inches above the highest water in the Salt Lake, but is 5 feet below the highest flood-marks during the rains in the Hooghly and Tolly's Nullah. It follows that the natural direction of the Drainage of Calcutta would be towards the Salt Water Lake and the Nullahs in connection therewith.

The Circular Canal, which environs the North and East sides of the Town as far South as Entally, has however intercepted the flow Eastward, and now receives a great portion of the Drainage of Calcutta.

Entally is 3 miles from the North and 1½ miles distant from the South end of the Town. It forms now the most convenient exit for the Drainage of the Town, and the distance from it to the most suitable point of discharge into the deep water channel of the Salt Lake, by the shortest and most direct route, is 2 miles to the head of Tengrah Creek, thence 1½ miles to its junction with the Main Channel—total length 3½ miles.

Nature of surface soil.

The upper artificial stratum of rubbish or mould is of varying consistency and tenacity, but is generally found sufficiently firm to allow of Drains of moderate dimensions, such as 6 feet high, being constructed in it without extraordinary difficulties or precautions, being requisite.

Fort William Borings in 1837 & 1838; and previous to that by Colonel Garstin, from 1805 to 1820, and by Dr. Strong, Mr. J. Kyd, and Mr. D Rose, from 1829 to 1833. (Asiatic Society's Journal, Part II.) (And this Report, "Water Supply.")

From the borings which have been made from time to time in Calcutta and Fort William, it has been found that the surface soil is an alluvial sandy clay to the depth of about 10 or 20 feet.

Subsoil.

Below this, River sand occurs in beds of varying thickness, from the depth of 15 to 30 feet; after which the soil again becomes more clayey. As it descends, it becomes more of a blue clay, which increases in compactness, till it ends in peat beds at a depth of about 50 feet.

In some places, as about Entally and the Circular Canal, the peat is nearer the surface. Beyond Tolly's Nullah to the South, the sand comes much nearer the surface, and is within 12 or 14 feet. Hence many of the Tanks here do not hold water for a length of time.

Borings made with a view to obtain springs of fresh water at different times have been totally ineffectual; nevertheless, it is certain that it is only necessary in the rains to dig a very shallow hole to have it soon filled with water in any part of Calcutta.

Below the peat, sand and gravel strata occur, and at 120 feet a bed of quicksand loose and full of water, has been penetrated.

Tanks.

Although the Hindoos prefer River water for drinking and domestic purposes, yet much of what they consume is derived, and often necessarily, from the numerous Tanks throughout the Town. These amount in number to 1,043, and besides these, which include private as well as public Tanks, there are great numbers of dirty pools and puddles, to abolish which must be the aim of any well-devised sanitary scheme, as all accounts concur in describing them as a fruitful source of disease, and it might be added, of that Calcutta plague, musquitoes.

As they are no doubt convenient in some respects to the Natives for washing purposes, their abolition would be a hardship, until water in some other form was supplied to the Town.

Wells.

Wells are numerous, but their water is brackish, and is only used for bathing and washing purposes, and only when no better is procurable.

As they cost so little however, only 4 or 5 Rupees, and as water is certain to be found within a few feet of the surface, they are very common.

City of Calcutta.

The European and Native quarters of the City are distinct, and may, for general purposes, be divided by a line drawn West and East, from Chandpal Ghaut through Esplanade Row and Durrumtollah to Entally.

To the North of this (a distance of 3 miles) is the Native City; South of it, for 1½ miles, is Chowringhee, the European portion.

The former extends the whole width of the City, from the River to the Circular Canal, while the latter divides that breadth equally with the Fort and Maidan.

Upjohn's Map, 1792-93.

The Town of Calcutta, half a century ago, was concentrated about the present Custom House (then the Old Fort), in a space about 1¼ miles long by ½ a mile broad; Esplanade Row (then in existence under that name) being the South boundary, Cossitollah Street the boundary to the East; while a mile further Eastward, down an avenue, and across the fields, the line of the Mahratta ditch was traced, which, with some small field works, formed the defensive line of the City. Half a mile to the North of the Fort, or about the present Steam Ferry Ghaut, the Northern boundary might be taken, though but ill-defined, owing to scattered huts; while beyond this were fields, huts, and winding paths.

In process of time, habitations thickened about these paths, and they became the streets of the extending City. Hence it is, that several are so narrow, many, particularly of those running West and East, being only from 12 to 20 and 30 feet broad from house to house, and at the same time very tortuous.

Many improvements were subsequently effected throughout Calcutta by the Lottery Committee in and previous to the year 1826. The funds which they obtained were laid out in the improvement of the City, and to them we owe Cornwallis Street, an unbroken line North and South (to Park Street), 4 miles in length; also Amherst Street—these two streets being 60 to 65 feet broad; also many improvements on the River Bank and in all parts of the City, as may be seen from Plan No. ? of Appendix VII. and from the following record of their works executed from time to time.

The general opinion, in which the Medical Faculty strongly coincide, is decided on the benefit of opening up a few more of such wide streets. Dampness and effluvia would thus be diminished, and the general health and cleanliness much improved; but it is no easy task to break up the rights of a thickly-clustered and settled population.

The Improvements made by the Lottery Committee.

Numbered as marked on the Plan.

New Roads and Streets.

Creek Row.

Hare Street, from Bankshall Street to Strand.—Foot-path along the Balustrade from Chandpal Ghaut to the Chowringhee Sortie.

St. James's Street, including the Road round the Church premises.

27. Central Road, from Park Street to Shaum Bazar, which includes Wellesley Street, Wellington Street, College Street, and Cornwallis Street.

Rawdon Street.
Loudon Street.
Hungerford Street.
Theatre Road.
Moira Street.

22. Royd Street and Elliot's Road, extending from Central Road to the Circular Road.

24. Free School Street, from Kyd Street to Jaun Bazar 5th Lane.
Joratallao Street, from Free School Street to Central Road.
Jaun Bazar 5th Lane.
Lindsay Street (Eastern end.)
Sudder Street (East and West end.)
Clive Ghaut Street
Jackson's Ghaut Street.
Waterloo Street.
Colootollah Road.
Amherst Street, from Boitackhanna to Manicktollah Road.

28. Strand Road, from Chandpal Ghaut to Kidderpore.

Public Tanks and Squares.

Wellesley Square.
1. Wellington Square.
College Square.
Cornwallis Square.
Five Tanks in Hastings' Place.
Short's Bazar.
Mirzapore Tank.
Colootollah Tank.

Obstructions removed for widening the following streets :

10. Hastings' Street.
13. Bankshall Street.
15. Mangoe Lane.
16. Cossitollah.
17. Weston's Lane.
22. Kerr's Lane.
23. Kyd's Street.
Joratallao Street.
32. Park Street.
33. South Colinga Street.
35. Clive Street.
36. Chitpore Road.
Bonfield's Lane.

Surface Drains were made to the following streets:

30. Chitpore Road, Nabootollah Street, Sankareetollah Street, Hyderam Banerjee's Lane, Serangee's Lane, Muddun Dutt's Lane, Gour Day's Lane,

Doorgachurn Pittooree's Lane, Bancharam Unkoor's Lane, Bapareetollah Street, Emaumbarry Lane, Short's Bazar Street, and Bunneaputty Street.

Other Miscellaneous improvements.

31. Steam Engine and Reservoir at Chandpal Ghaut, also the Balustrade of the Esplanade.
9. Entrance to the Town Hall.
2. Simlia Drain.
3. Dinga Banga Street.
4. Durrumtollah Drain and Aqueduct.
5. Aqueduct and Balustrade in Chowringhee Road from Durrumtollah to Park Street.
6. Balustrade and Foot-path from Chandpal Ghaut to the Chowringee Sortie.
7. Balustrade from Park Street to South-east corner of Government House.
8. Chabootrah on the Course.
11. Ditto King's Bench Walk.
14. Tank Square Tunnel and Gate.
18. St. James's Chapel.
19. Camac Estate.
20. Short's Estate.
21. Road opposite the Theatre.
25. Road from Durrumtollah to Jaun Bazar Road.
26. Road from Park Street to Colinga Bazar.
29. New Ghaut in Clive Street.
34. Middleton Row Drains and Balustrade.

Improvements to the end of 1826 *and colored pink on the Plan.*

The Strand Road continued from Chandpal to Hautcollah.

The Central Road completed to Shaum Bazar, and now includes.

Wellesley Street and Square.
Wellington Street and Square
College Street and Square.
Cornwallis Street and Square.
Waterloo Street.
A further widening of Clive Street and Bonfield's Lane.
Amherst Street.

Number of Houses (Simms's Report) and Population.

The number of Pucca Houses in the City is 13,120, of common Huts 49,445. The North Division, which has always been distinguished for assessment and other purposes from the Southern, and as adopted by Mr. Simms, is situated to the North of the line of Loll Bazar and Bow Bazar, and contains Huts 35,545

While the South contains 13,900

Total 49,445

Of the Pucca Houses 9,588 are in the North, 3,532 in the South Division—Total, 13,120.

	Pucca Houses.*	Huts.
Population. In 1821 there were estimated to be in Calcutta	14230	51287
In 1831 by Captain Steel ditto	15303	54773
In 1837 by Captain Birch ditto	14623	50871
In 1850 by Mr. Simms ditto	13120	49445
	57276	206376
Average	14319	51594
If the population be reckoned from these at the usual average of	10 &	5
	143,190	257,970
It would give the inhabitants and the total population ...	401,160	

Mr. Simms, obtained, by an average calculation, 361,369, as the amount of the population, which he thought rather under than over the mark. We may therefore be justified in assuming it certainly at 400,000† within the present Supreme Court limits; but if we include the populous suburban districts without these limits, it is probably not less than half a million.

In 1800, by a Report of a Police Committee, the population was estimated at 500,000, and in 1814, by Sir E. Hyde East, at 700,000.

A considerable proportion of this population is migrating or non-resident.

In 1821, the Magistrates estimated that, out of a population of 305,600 souls, 100,000, or one-third, was non-resident.

These live on the immediate borders of the Town jurisdiction, and may be considered as part of the population to be provided for in a Scheme for Drainage, because, whether in domestic or in mercantile employ, they spend the entire day within the confines of the City.

Boundaries of the City.

The limits of Calcutta City proper, within the jurisdiction of the Supreme Court, as settled in 1794, may be defined generally thus:—On the North, the Circular Canal, as far as the Dum-Dum Road; on the East, the Circular Road or Mahratta Ditch; South, Tolly's Nullah, excavated in 1795; West, low water mark on the right bank of the River. These limits have existed up to the present time, but are now about to be re-adjusted by an Act of the Supreme Council.

* The average of inhabitants to each Pucca House is taken by Mr. Simms at 8·7; but others have always taken it at 10. (*Vide* Simms's Report)—Appendix.

† The population of Madras is supposed to be 700,000, that of Bombay 500,000.

The former is 61 to 63 feet wide.

Wood Street 47.

Chowringhee Road is 57 to 98, average 82 feet.

Free School, Camac, Rawdon, and Loudon Streets, the other principal North and South streets, respectively average 50, 79, 66 and 62 feet broad.

East and West Streets.

In the cross direction, East and West, the chief street which divides the City into two drainage areas, North and South of Entally, is Durrumtollah prolonged past the Government House and Esplanade Row to the River at Chandpal Ghaut.

The space North of this, which it has been stated is 3 miles long, is divided, by seven streets from West to East, at an average distance of 3 furlongs or $\frac{3}{8}$ of a mile apart, into eight parts. These streets are with their repective widths as follows:—

1. { Koomartolly Street, near Cassy Mitter's Ghaut, 20 feet.
   { Balaram Ghose's Street, 24 feet (ill-defined.)
2. Sobah Bazar and Rajah Nubkissen's Street, 44 and 34.
3. Nimtollah and Manicktollah, 37½ and 26 to 36, average 41 (winding).
4. Sukeas' Street (ill-defined), 17.
5. Cotton Street and Machooa Bazar, 20 and 30 to 60, average 44.
6. Moorgyhatta and Colootollah, 25 and 45.
7. Loll Bazar and Bow Bazar, 69 and 55.
   Durrumtollah, 72.

In the South part of the City, the length of which is 1½ miles, this distance of 12 furlongs is not so regularly divided into portions of about equal width, as in the North part. The great thoroughfare, Park Street, runs in a diagonal direction through it, and divides it unequally; nevertheless, there is no want of streets running East and West through parts of it, and which will afford tolerably regular, though smaller, sub-divisions than those of the North City.

These drainage lines, and their widths, are—

Lindsay Street and European Asylum Street ...	32 and 24 feet
Collingah Street	Average 36
Park Street, 53 to 79	Average 62
Middleton Street	 38
Theatre Road	Average 63
Circular Road (as before)	Average 95

It will be observed, from a Plan of Calcutta, that the East and West lines are not so regular as the great North and South ones—Chitpore Road and Cornwallis Street. Of the eight East and West streets, in the Northern Division, the four to the South are straight; but of these, only Loll Bazar and Durrumtollah, (the two nearest to the European part of the City,) are of good width throughout.

Some parts of the two streets lying next to the North from Loll Bazar, *viz.* of Moorgyhatta, are only 18 to 20 feet wide, and of the next, *viz.* Cotton Street, even less, or as little as 13 feet wide, from House to House, including the road-side drains.*

* In many of these narrow streets, the height of the Natives' Houses, on either side, is as much as 40 and 50 feet

The four Northernmost are both narrow and irregular, and drains must either run a devious course through them, or the streets themselves, must be remodelled if regularity is demanded.

Squares.

There are but few Squares in comparison with the extent of Calcutta, and for the most part, they result from the labours of the Lottery Committee; they are at present 15 in number, the principal of which are Government Place, Tank, Cornwallis, Wellington, and Wellesley Squares. Nearly all hold large tanks of fresh water, and are much resorted to by the poorer classes for recreative purposes, while the Maidan and its Course are more frequented by the equipages of the wealthy. The only other public place of amusement is the Botanical Garden, situated on the Western shore of the Hooghly, at the South end of the Port of Calcutta.

Places of recreation.

Quays.

The River bank, from Aheeritolah Ghât down to Garden Reach, with the exception of the portion opposite Fort William, may be termed one continued wharf for the convenience of the Shipping of the Port. The chief Docks are the Marine Docks at Kidderpore and those on the opposite side of the River at Howrah.

Public buildings.

The prominent edifices are Government House, the Mint, Town Hall, and St. Paul's Cathedral, the Medical College Hospital, &c. There are besides 30 Churches or Chapels of different persuasions, one Synagogue, and one Parsee Temple; but there is a paucity of remarkable Hindoo Temples and Mosques, the chief ones to be noted, being Kalighat and the Mahomedan Mosque in Durrumtollah. Among the Monuments, may be reckoned the Ochterlony Column, the Burmese Pagoda and Prinsep's Ghaut on the River side.

Cemeteries.

The European Cemeteries of Calcutta lie chiefly about the Eastern extremity of Park Street, in the South-east corner of the City.

They consist of two old ones on the North and South sides of Park Street, formerly used for Protestants, but now filled up.

The one at present in use by members of the Church of England is in Circular Road, a little to the North of the Eastern end of Park Street. In this, there is also ground, which has been lately made over to the Roman Catholics, and a portion is appropriated to Dissenters.

The Military Burial Ground is in the Bhowanepore Road.

The Scotch Burial Ground is to the East of the Old English one in Circular Road.

The French Burial Ground is on the North side of the end of Park Street.

The old Roman Catholic ground, now nearly filled up, is in Circular Road, just beyond Bow Bazar.

The Jews' Ground is in the heart of the City, near the junction of Colootollah and Chitpore Road.

The Museum is at the Eastern extremity of Park Street.

The Armenian and Greek, North of Tiretta Bazar.

The Mussulman Burial Grounds are, first, a large one South of Chowringhee, across the Circular Road, called Kasia Bagan, and two others in the Northern part of the

Circular Road, outside the Mahratta Ditch, near Manicktollah. The former has often been complained of as a nuisance from its situation directly South of the City, and from the practice of not burying sufficiently deep and not surrounding the Cemetery with a wall.

The Church of England Burial Ground, in Circular Road, is nearly full, and it will very shortly be necessary to establish a new one, which it is to be hoped will be moved further from the City, and more in conformity with a position, such as is generally in the present day assigned to Cemeteries, or in the direction of the least prevailing wind.

See Evidence in Municipal Committee Report.

There is no great degree of nuisance experienced from Burial Grounds in Calcutta. Generally, they are well walled in, watched, and guarded; and except from the wet nature of the sub-soil and the drainage into the ditches or drains in the immediate neighbourhood of the ground, there is no more, or indeed so much, unpleasantness experienced, as in less humid and in cooler climates, where decomposition is less rapid and complete, and sepulture perhaps less carefully attended to.

The requisite land not being so expensive to obtain near it, it does not also become necessary to use the same graves more than once, as is frequently done in England until a Church-yard becomes positively and glaringly offensive.

The Parsee Temple of Silence is at Chingrechatty, near Baliaghatta, and the Hindoo Burning Ghât at Nimtolah. The latter is a wide space on the bank of the River, enclosed by high walls, within which are burnt, by an establishment maintained for the purpose, all the dead bodies of the better classes of Hindoos who die in Calcutta.

Such an establishment in the heart of the City cannot fail to be a nuisance, and the Committee would gladly see it removed further down the River.

Bazars.

The Bazars of Calcutta are numerous, being fifty-eight in number. These are chiefly Native Bazars, and confined to the sale of piece and other such goods, grain &c. &c.

The only ones to which Europeans resort for the necessaries of life, and which may be called Markets, are two, one in Durrumtollah, at the corner of Chowringhee Road, and the other, called Tiretta Bazar, about half a mile further North beyond Loll Bazar.

Of these, the Durrumtollah one is that most resorted to, and both are well supplied and crowded. They are built, however, in the Native style, and though they have become Europeanized, as regards the products brought for sale, from the yearly increasing demands for these, yet they in no way conform to the ideas entertained in European countries of spacious, well-ventilated, and well-cleansed Markets. On the contrary, their pathways are barely 6 feet broad, and they are, in all respects, inconvenient; being confined as to space, ill-drained, dirty, and unsavoury. It is not very surprising that these faults have not been remedied under present customs, as Europeans do not often care to visit them; but a reform in the Markets is no doubt one of the desiderata of Calcutta, and the time will come when it will be demanded by the majority on economical as well as sanitary considerations.

There are many Native Bazars where provisions and esculents of all kinds are sold, as Sobah Bazar, in the North of the City on the Strand Bank; also several, as Rajah Sookmoy's, Hautkola, Byeuntnauth Moonshee's, and Coseenath Baboo's.

Most of these are complained of as being dirty, and causing offensive smells, but this is probably to no greater extent than would be immediately and effectually removed by a good supply of water.

Evidence in Municipal Committee Report.

The chief Abattoirs are situated in the South-Eastern part of the City, about ½ a mile beyond the extremity of Park Street, in Circular Road.

Abattoirs.

There are others just beyond the Narkuldangah Suspension Bridge and the Circular Canal.

Although exceedingly filthy places, and managed without any particular care or attention being paid to their drainage, yet, from the situation being favorable, outside the Town, and the drainage, such as it is, being in the other direction towards the Lake, no great nuisance is experienced from them.

The Hospitals are the General Hospital, which is situated towards the South part of the Maidan, and in the City there are two of importance, the Medical College and the Chandney or Native Hospital.

Hospitals.

It is a very general opinion among the Medical Faculty, that much disease, such as Hospital Gangrene, and a too frequently fatal termination of amputation and other cases, is due to the open and fetid drains, which are found in the neighbourhood of the Hospitals. On this subject, there is, we believe, no necessity to enlarge. All Medical testimony is concurrent, from the time such subjects first attracted attention, in saying that much of the sickness and Cholera prevalent at times in Calcutta is due to the stagnant and open drains, which every where abound.*

Municipal Committee Report.

As regards the converse effect of the Hospitals themselves on the drains, it does not amount to much, in the case of the Chandney Hospital; and whatever it may have hitherto been with the Medical College Hospital, it will not continue much longer, for that Hospital is now supplied with a small Steam Engine, which pumps an ample supply of water for its especial use, and by means of which it will be fully and perfectly cleansed, and its impurities diluted and effectually carried away from its own immediate neighbourhood at least.

Some nuisances exist in the City of Calcutta, which materially affect the drainage and its sanitary condition—such are the collections of the Tola Mehters and Gwalas, the latter of whom keep large numbers of cows for the supply of milk. The accumulated ordure and night soil is often retained contrary to the Regulations (which provide for its being carried forth from the City,) till it amounts to a large quantity, and then, on the occurrence of a favorable opportunity of rain falling, let loose into the drains. Establishments for curing Green Hides, the stench from which is intolerable, also exist in some parts of the City, much to the annoyance of their neighbourhood.

---

* On this subject, see "Water Supply."

Present state of Drains.

The present Drainage of Calcutta is towards the River, Circular Canal, Tolly's Nullah, and Southern Salt Water Lake.

The course of the main drains leading to the Circular Canal is very irregular. They are evidently, that is, those North of Colootollah and Mirzapore Road, the natural courses the rain water must have made before the streets were formed.

Native Town.

There are two principal mains North of Colootollah and Mirzapore Road; the first is the Manicktollah drain, and the second is the Mutchooa Bazar drain. These two mains carry off an immense quantity of water, as will be perceived, on examining the Map. The former empties itself into the Canal at the Manicktollah Bridge, and the latter at the Narcoaldanga Bridge. There are several smaller main drains at the North end of the Town, which are connected with the Mahratta Ditch, and the water from them partly flows into the Canal close to the Dum-Dum Bridge, and between the Barrackpore and Chitpore Bridges, and also a portion of it into the River through the Mahratta Ditch.

The third main is a large under-ground drain, commencing from the Chitpore Road, and running on the South side of Colootollah and Mirzapore Road into the Mahratta Ditch. The water of the Mahratta Ditch from this point flows Northward, till it enters the main outlet of the Mutchooa Bazar drain.

The fourth main runs along the South side of Bow Bazar, and is an under-ground drain. It commences from Tank Square and enters the Mahratta Ditch at Boitackhanna. There is also an open drain running on the North side of the same street, commencing from Chitpore Road and entering the Mahratta Ditch. The water from both these drains enters the Mahratta Ditch and flows Northward, till it enters the Mutchooa Bazar main outlet. Owing to the drainage waters of several main drains emptying themselves into one outlet drain, and this outlet being only large enough to carry off the water from one main drain, a considerable portion of this part of the Town is under water during heavy falls of rain.

The fifth main drain runs along Durrumtollah. There are two drains along this street. The Southern one is an under-ground drain, the Northern one was formerly an open pucca drain, but a large portion of it has been arched over by the proprietors of the houses along side. These drains commence from the Esplanade, and part of the water from the maidan flows into the Southern under-ground drain. The Northern one receives the drainage from Cossitollah, and a greater portion of the drainage of the portion of the Town lying between Bow Bazar and Boitackhanna on the North and Durrumtollah on the South. These two drains empty themselves into the cess-pit formed at the head of the Branch Canal, Entally, an immense quantity of silt is carried down them into this pit, which is yearly excavated. The drainage from the

Chowringhee.

Jaun Bazar Street drains passes into the drain on the South side of Dhurrumtollah. The portion of the Town lying between Jaun Bazar, Wellesley Street, Park Street, and the Circular Road, has several minor main drains, which runs from West to East, till they enter the large ditch along the Western side of the Circular Road. The water from this ditch flows Northward till it enters the Durrumtollah outlet. There are two outlets in the Suburbs, one opposite Elliot's Road and the other on the North

side of the New Burial Ground, which relieves the above ditch during heavy falls of rain.

The sixth main drain runs along Camac Street. One branch commences from Chowringhee Road and runs along the North side of Park Street and is an under-ground drain, and another commences from Jaun Bazar 5th Lane and is an open pucca drain only a portion from Kyd Street to Park Street being arched over. Both these branches enter the Camac Street drain. The main drain of Camac Street is arched over from Park Street to Theatre Road; the remaining portion is a cutcha ditch. The water from this drain enters the Mahratta Ditch, which runs along side of the Circular Road till it reaches the Bhowanipore Road, where it turns Southward, entering Tolly's Nullah close to the Foot-path Suspension Bridge, Allipore.

The drainage of Short's Bazar is carried off into the Mahratta Ditch by the two open pucca drains, one on the East side of Rawdon Street and the other on the West side of Loudon Street. The water of the Mahratta Ditch from these points flows Westward till it reaches the Bhowanipore outlet.

During heavy falls of rain, the water from the Mahratta Ditch is relieved by two suburban outlets, one on the East side of La Martiniere Girl's School, and the other opposite Rawdon Street. The whole of Chowringhee is drained into the Camac Street main drain. The drains are pucca surface drains, with the exception of a portion of Harrington Street and Little Russel Street, where they are under-ground.

A portion of Theatre Road from Little Russel Street to Camac Street is cutcha.

Surface drains.

Most of the streets in the Northern Division have cutcha surface drains running along both sides. The water from these flows into the minor ditches, which again are connected with the main drains, which are also cutcha. All these minor and main drains are made without any regularity. They appear as if they had been formed by nature. In the Southern portion of the Town, where the thoroughfares are made with some regularity, the drains are better formed, but still not with sufficient fall to carry off the water freely. Most of the surface drains are so injured by the impregnation of saltpetre, that it will be necessary to re-construct the whole, if a new system of Drainage is carried out.

Under-ground drains.

There are very few under-ground drains in the Northern Division. They are as follows:—Colootollah and Mirzapore main drain, Chitpore Road from Colootollah to Lall Bazar, Lyon's Range and Bonfield's Lane. Small portions of others are arched over, but not to any extent.

In the Southern portion of the Town, the following are under-ground drains:—

Bow Bazar and Boitackhanna (South side); Lall Bazar; Tank Square, East, West, and South; Hare Street, North, (this supplies Tank Square with water from the River); Hastings' Street, North; Old Post Office Street; Esplanade Row, East, and Esplanade Row, West; Government Place, West; Old Court House Street both sides; Mangoe Lane; Mission Row; a portion at Raneemoody Gully; Waterloo Street, South side; Cossitollah, West side (there is a drain on the East side of Cossitollah which is covered with planks and road materials, but it has to be opened out every year for the purpose of cleaning it and renewing rotten planks—this is also the case with several lanes leading from Cossitollah); Durrumtollah South main

drain, and partly on the North side; Chowringhee Road, from Cossitollah to Maxtons, Lane; also from the Small Cause Court to Park Street; a portion in Kyd Street; and also in Joratullao Street; Park Street, North side, from Chowringhee Road to Camac Street; also, on the South side, from Chowringhee Road to Middleton Row; Camac Street, from Park Street to Theatre Road; Harrington Street, from Chowringhee to Little Russel Street; and Little Russel Street, from Harrington Street, to Theatre Road.

New and old drains.

The only under-ground drains that have been newly constructed are those in Old Post Office Street, Park Street South, Harrington Street, and Little Russell Street, Esplanade Row East, Government House West. The remaining Drains are very old.

Enumeration of River or Western outlets.

There are twenty-three outlets into the River from Chandpaul Ghaut to Aheeretollah Ghaut.

The following are the places :—

2 Chandpal Ghaut, N. and S. side.
1 Colvin's Ghaut, N.
1 Opposite Metcalfe Hall.
1 Police Ghaut, S.
1 Coilah Ghaut, S.
1 Old Fort Ghaut, S.
1 Opposite Bonded Ware House.
1 Clive Street Ghaut, N.
1 Opposite Ganges Steam Company's Office.
1 Jackson's Ghaut Street, N.
1 Steam Ferry Ghaut, N.
1 Durmahattah Ghaut, N.
1 Burrah Bazar Ghaut, N.
1 Meerbhur's Ghaut, N.
1 Juggernath Ghaut, N.
1 Khurrooah-Postah Ghaut, N.
1 Sibtollah Ghaut, N.
1 Prosooncoomar Tagore's Ghaut, N.
1 Jorah Bagaun Ghaut, N.
1 Nimtollah Ghaut, S.
1 Manick Bose's Ghaut, S.
1 Aheeretollah Ghaut, S.

Total 23

From Aheeretollah to Baug Bazar, there are

4 Main Outlets.
1 Ruth Ghaut.
2 Large open drains from Coomartollee.
1 Mahratta Ditch.

Enumeration of Canal and Eastern and Southern outlets.

The principal outlets for draining the Town into the Circular Canal are those alongside of the Dum-Dum Bridge, Manicktollah Bridge, Narcoaldangah Bridge, and the one leading into the cess-pit at the head of the Branch Canal, Entally. The outlets further South are.

1 opposite Elliot's Road.
1 North of the new European Burial Ground.
1 North of the Scotch Burial Ground.
1 opposite Theatre Road.
1 East of La Martiniere School for Girls.
1 opposite Rawdon Street.
1 Bhowanipore outlet, which enters Tolly's Nullah.

Total 7

The drainage from the first six mentioned above runs towards the Eastward or Southern Salt Water Lake.

Rain fall drainage.

All the main drains carry off the rain water, but with the exception of those about Tank Square and Government House, which empty themselves into the River, and the Durrumtollah drains, are yearly cleansed by hand. The reason why these drains never require cleaning is owing to the larger quantity of water which flows into them and carries off the silt.

There is no regular system of Drainage in the blocks of the Town, and this portion of the work in a new system of Drainage will present many and great difficulties to carry it out effectually. It will be necessary to open out new streets and to have a good supply of water.

Nature of house drainage.

The native privies are generally constructed by raising the floors a few feet to enable the sweeper to clean the place below. The door leading to the lower part is alongside of the street or public drain, and there is no communication to it from the premises. A perforation is made in the upper floor, through which the filth falls either into earthen vessels placed below, or, as is generally the case, on to the lower floor, whence the sweeper removes it. This floor is never washed, and they are usually not more than 3 feet high. These places are not cleaned, and the soil removed every day; in some places it is allowed to remain for weeks and months. Some natives have larger places, and the filth is removed once a year. Hundreds of privies along the sides of pucca drains have not this arrangement of a double floor, but the soil is allowed to fall into the drains by a slope made for the purpose, and there it remains till the rain washes it away. Other natives have balconies over-hanging the drains, into which the soil falls through holes made for the purpose in the floor. These balconies and privies along the drains are made where the Overseers and Conservancy Peons cannot enter to be able to give evidence against the parties. The privies belonging to the natives are more a nuisance to the neighbours and the passers-by than to themselves, and often complaints are made of a neighbour's privy, when the one belonging to the complainant is in a more filthy state. The night-soil from

European houses is collected by the in-door Mehters and removed the following morning by the Tolah or out-door Mehters. These Tolah Mehters are only employed for removing night-soil. All that is collected by them during the day is kept in large vessels and removed the next morning to the night-soil ghaut and thrown into the river. The places where these Tolah Mehters reside, and where they keep the night-soil, can hardly be approached. During the rains it is kept for days, instead of being carried to the ghaut, and this is done with the expectation of a heavy shower of rain, which, if they are favored with, the whole is disposed of into the public drains. They are so well aware of the trouble saved in this respect, that they invariably fix on spots where there is a good drain along side. The nuisance arising from these places is worse than that from the public Tatties.

Public Tatties.

The soil from public Tatties is collected during the day and removed to the ghaut at night. The owners of these tatties also take advantage of a heavy shower of rain for throwing the soil into the drains.

Drainage of public establishments.

The liquid matter from Tanneries, Fish Markets, &c., all flows into the public drains, and the sweepings are thrown into the public street, to be removed by the Conservancy Carts.

Cook-rooms and Stables.

The same is the case as regards the Cook-room, Stable, and Bazar refuse, Native and European, and the nuisance caused by this is very great.

Final out-flow from drains.

It is only during the rains that the filth which is washed into the drains flows into the Canal; during the dry season the liquid matter is generally absorbed into the ground in the cutcha drains, and the more solid particles are deposited. This is not the case with drains that have pucca floors, for instance the Durrumtollah drain. The whole of the sewerage matter from this is washed into the Entally Pit and thence removed by excavation once a year.

Excavation from drains.

The cutcha drains are excavated every dry season. This is also the case with most of the underground drains and open masonry drains. The silt which is thus removed, consists chiefly of road washings mixed up with night soil and cook-room refuse. In the Northern part of the Town, a large quantity of cattle manure is allowed to wash into the drains.

The coolies are sent in through the openings, and the deposit is taken out and thrown on to the sides of the streets, and removed when sufficiently dried. The nuisance experienced by the neighbourhood, while an underground drain is being cleansed, is great, as the sewage matter is kept for some time on the road side, but the excavations from cutcha drains can generally be taken away at once as the liquid matter has already soaked into the soil.

Conservancy.

The arrangements for the conservancy and general sanitary condition of the City are confided to the care of the Municipal Commission, composed of three Members, of whom the Commissioner of Police is ex-officio President.

Drainage Committee.

APPENDIX No. II.

THE RIVER HOOGHLY.

THE River Hooghly flowing in a direction from north to south on the western boundary of the Town, forms the Port of Calcutta*, thence down to its embouchure into the Bay of Bengal, it receives some important tributaries from the country on the west, and runs a course of 86 miles to Saugor Point, the navigation of which is much impeded and rendered difficult at all seasons, by the formation and constant changes in position of numerous bars and shoals.

Fall.

The Height of Calcutta above the sea, is by the Surveyor General's Barometrical observations 18·16 feet.

The distance from Calcutta to Saugor Point is 67 miles by land in a direct line and 86 by the river. The declivity therefore of the ground is about 3 inches per mile.

Above Calcutta, the fall is greater. According to Mr. Simms, the difference of level between Fultah 13½ miles distant, and Calcutta, is 12 feet or 10⅔ inches per mile.

The surface fall of the River is of course somewhat less than this, and being in its ordinary state 2·6 inches per mile, is not very different from that of the Mississippi, which is ascertained by Professor Riddell of New Orleans to be (at high water) 1½″ per mile.

Major Rennell gives the mean fall of the Ganges as 4 inches per mile for a distance of 1,320 miles including 300 of Delta. The Nile is 7 to 8 inches; and the Po is 7 inches near its Delta, and 8 or 9 inches per mile higher up.

Width.

Opposite Calcutta the River averages about 2,000 feet in width, being at the narrowest point in the centre of the city at the Railway ghât, 1,700 feet broad; Opposite Nimtollah ghât, 2,200 feet. Above and below these points, the river widens considerably.

* More strictly defined, the Port of Calcutta extends by order of the Government from boundary pillars erected at Aherutollah Ghât, near the north of the town, down to similar pillars on both sides of the river at the house of the Superintendent of the Botanical Garden.

The breadth of the River is less now than it was half a century ago, owing chiefly to the constant encroachment on it by throwing in earth and rubbish over the city bank. In maps of that period it is laid down as exactly half a mile broad at the narrowest point opposite Howrah ghat. This would make a difference from the present breadth of about one furlong.

Depth.

The River has a maximum depth of about 40 feet below the lowest water mark or zero of the gauge on the sill of Kidderpore Dock, and in its ordinary state it has a velocity of 3 to 4 feet per second.

Shipping.

The number of vessels frequenting the Port is now very large, and will continue to increase with the increasing trade of Bengal.

During the year 1856, the number in Port at any one time, has ranged from 176 to 235, or on an average of the twelve months, 201. This is exclusive of native craft, of which the arrivals in the year have been about 300, aggregating in round numbers 25,000 tons. And there are besides from 400 to 500 Cargo boats constantly plying between vessels and the shore.

Looking to the very large number of men, European and Native, thus constantly employed on the River in the immediate vicinity of the shore, sanitary considerations alone must be held to offer a sufficient obstacle to the admission of the sewage of Calcutta into the river.

Height of Tides.

The level of the surface water in the Hooghly has been accurately obtained, by the readings on the gauge at Kidderpore, which are regularly recorded in the Marine Superintendent's Office. The tables of the rise and fall of the tides during the years 1823 and 1855 procured from that source, show that the time of lowest high tides is in the months of December, January and February.

During the month preceding the above period, and in the three months following *viz.*, in November, March, April and May, the River may be said to be in an ordinary state, and for the rest of the year *viz.*, from June to the end of October, in a condition of overflow or inundation.

The neap tides rise on an average from 6·25 feet up to 12·83 feet, on the Kidderpore Gauge. The time taken in rising is $4\frac{1}{4}$ hours, while the fall occupies $8\frac{1}{2}$ hours. The accompanying diagram* prepared from observations taken on the 12th August, 1856, will show the Neap Tidal curve of rise and fall for that Month of the year and the Diagram* which follows will show the rise and fall of the Spring tide observed on the 18th August 1856, (Moon's age, 18 days,) which took $2\frac{1}{4}$ hours to ascend, and $9\frac{3}{4}$ hours to fall.

---

* Vide plans No. IX and X of Appendix VII.

On an average the spring tides rise from 4·75 feet up to a height of 17·41 feet above datum at Kidderpore. The bore up the Hooghly is very strong during the high spring tides; the wave opposite Calcutta is sometimes 6 feet in height, and it continues to be felt far beyond Barrackpore, 15 miles higher up the river. The greatest flood level ever attained was in 1823 when the reading on the gauge was 24 feet above datum, and the River overtopped the bank in many places along its margin.

The diagram* attached exhibits the levels of the high and low water of the Hooghly from 1806 to 1834. The irregular line formed by the highest low water neap tides, exhibits the true condition of the freshes in each year; 1816 being a year of scarcity, and 1823 one of over-flow.

The chief points to be noted in the recorded Tidal observations, are the heights of highest high, and of lowest low water, in the two seasons of the Rains and the dry weather.

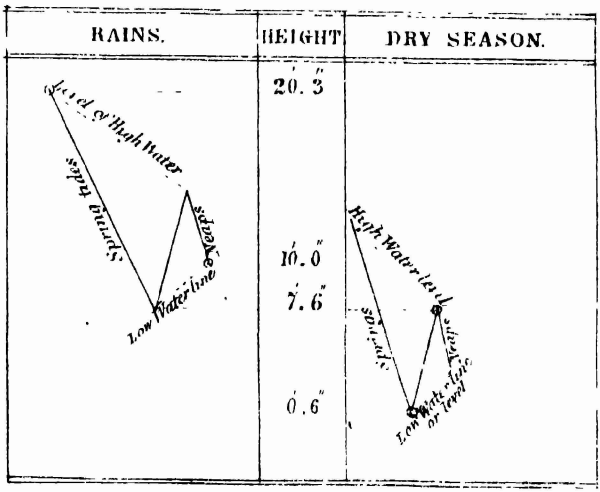
The *highest* High water during the year occurs in the rains spring tides when it is 23 to 24 feet, according to the register of actual observations made in Kidderpore Dock-yard. The *lowest* High water is in the dry season neaps when it is 9.′ 2″.

Again the *lowest* Low water all the year round, is in dry weather springs 1′. 10″.

And *highest* Low water is in the rains neaps 11′. 3″.

The accompanying diagrams will show these levels.

Diagram 1 from Mr. James Kyd's observations at Kidderpore Dock-yard from the year 1806 to 1828.



* Vide plans XI of Appendix VII.

Diagram 2 from the Khiderpore Dock-yard tidal register, from the year 1845 to 1853.

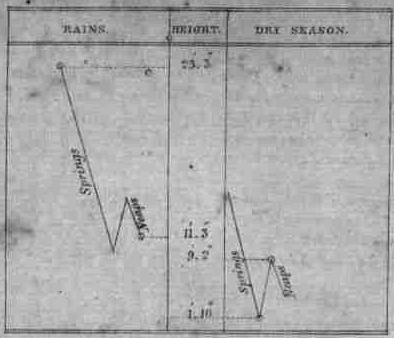
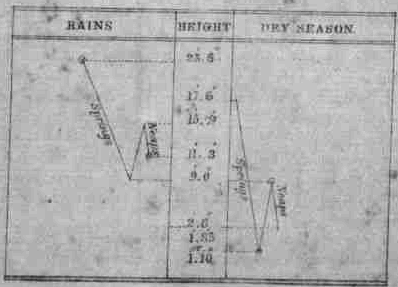


Diagram 3 from Mr. Simms' report, in which the levels are also taken from the Dock-yard register from 1844 to 1847.



The levels of the foregoing Diagrams are *mean* levels, and are the only ones available from actual observation extending over any length of time.

Flood Tides.

The influence of the flood tides extends as far as Santipore, 75 miles above Calcutta, or 160 miles from the sea, in the months of March and April when they run with the greatest violence.

In the rains on the other hand, ships moored in the stream opposite Calcutta are not sufficiently affected at the time of flood to be swung round by it, although the tidal rise and fall may at the same time be from 3′ 6″ to 6 feet.

Rapidity of Current.

The velocity of the flood tide is great. From the outer floating light to Saugor Point, a distance of 35 miles it travels in one hour. From that to Calcutta it moves at the rate of about 20 miles an hour, travelling the 86 miles in 4 hours, and from that to Barrackpore nearly 15 miles further, it takes one hour.

Lieut. Garforth's and Hamilton's report.

The rapidity of the down stream current varies according to the season. In the rains it is from 4½ to 6½ miles an hour. In some places in the Ganges where the stream is narrowed or confined by rocks (as at Chunar) it is as much as 8; Rennell gives it at 4½; Mr. Lloyd the same; and measured at Delhi in the rains it has been found to be about 4 miles per hour.

In the dry season its velocity diminishes to 2 miles an hour and in the more sluggish parts to even 1 only.

Kyd's Memoir, Asiatic Society's Journal vol. xviii.

In the cold season the night tides are higher than the day tides. In the hot weather and rains the day tides are highest. The difference in the former is as much as 2 feet. In the latter 1 foot.

Moonsoon influence on Tides.

The strongest flood tides and the greatest mean rise of the tides occur in March, April, May and June, after the South West Monsoon sets in, which it does in the middle of March.

The river is in the most quiescent state in November, December, January and February, during the North East Monsoon, when the night tides are higher than the day and more rapid.

When the South West Monsoon commences in the middle of March, the wind is in conjunction with the set of the tides up the Bay of Bengal, and the general level of the River tides begins to be raised. It continues to rise through the rains till the change to the North East Monsoon in the beginning of November, when it again gradually falls.

There is thus an annual *ocean tide*, as it were, derived from the Bay of Bengal, which sets "up" (northward), for eight months March to November, and "down", for four months November to March.

The lowest tides are in those months November to March.

The height of the tides is supposed to be influenced by the prevailing winds of the season, in such a manner as to cause the day tides in the South West Monsoon, and the night tides in the North East Monsoon, to attain the highest levels.

Kyd's Memoir.

The explanation offered of this is, that the wind being strongest in the day time, wind and tide act together in the South West Monsoon, with their greatest force; but are opposed in the day time during the North East Monsoon.

Other causes are however believed to operate, though what these are it has not yet been ascertained, because the difference between the day and night tides, which is as much as 2 feet in the North East, and 1 foot in the South West Monsoon, is too undeviating to be derived from so variable an influencing cause as the wind.

Turn of Tides.

The annual tide tables, which are published, give the greatest height and the lowest level to which the water in the river rises and falls, and the times at which those points are reached. The direction of the surface current is not however in conformity with those times.

For one hour after the water has begun to fall from its highest level, the surface current still continues to run northward, or up the river.

And in like manner the tide level turns from its lowest point and commences to rise again on the gauge, more than an hour before the set of the current is changed from seaward to upward.

This is a curious and interesting circumstance, which is probably dependent on the laws regulating the commingling of the two bodies of salt and of fresh water coming from opposite directions, in a river; which laws are however as yet but imperfectly understood. In the latter case the under current of salt water, flows beneath from its greater specific gravity, and not being so much retarded as the surface velocity of the down stream, by the wind, &c., it advances up the channel with greater rapidity than the upper current, and thus pushing forward below raises the level of the stream, which yet on the surface is running oceanward.

In the former case it is not so readily accounted for, but it may arise from the mass below of the water being first influenced by the ebb of the ocean and being withdrawn, causing the level of the river to fall while yet the current on the surface is running up stream.

As regards the time during which the flood and ebb tide last, it will be necessary to refer to the tables of actual observations at Kyd's Dock yard. These as well as the calculations of the printed tide tables published annually at the *Calcutta Gazette* office, and some actual observations made by Mr. Turnbull C. E. during this year, are compared in the following tables. The first of which shows principally the *heights* to which the tide rose in the day and night during certain months of

the cold weather and rains of the year 1855, both by calculation and actual observation, and the remaining three compare the *time* of the tidal flow during the dry and wet months both from calculation and actual observation.

The differences to be noted in these will show the necessity for a regular set of observations throughout the year of both the time of the tides and the height to which they rise, and from which the true tidal curve at all seasons may be accurately known.

TABLE I.

Table of Spring Tides in the Year 1855.

Month.	Moon's Age.	Date.	By the Tide Tables.				By the Kidderpore Dock Guage.				Difference Tide Table more or less			
			Time.		Height.		Time.		Height.		Day.		Night.	
			Day.	Night	Day.	Night	Day.	Night.	Day.	Night	Time.	Tides	Time.	Tide.
			H. M.	H. M.	Ft. In.	Ft. In.	H. M.	H. M.	Ft. In.	Ft. In	Min.	In.	Min.	In.
December, ...		9	1—54		13′ 7″		1—45		13′ 11″		+9	—4″		
(New Moon,)	⊙			2—16		15′ 5″		2—0		15′ 10″			+16	—5″
		10	2—37		14′ 0″		2—15		14′ 0″		+22	0″		
				2—59		16′ 0″		2—30		15′ 10″			+29	+2″
		11	3—21		14′ 4″		3—0		14′ 0″		+21	+4″		
				3—42		16′ 4″		3—15		15′ 7″			+27	+9″
January, ...		18	1—58		13′ 9″		2—15		13′ 2″		—17	+7″		
(New Moon,)	⊙			2—15		16′ 4″		2—30		15′ 6″			—15	+10″
		19	2—37		14′ 9″		3—0		13′ 10″		—23	+11″		
				2—55		16′ 10″		3—15		15′ 9″			—20	+1′ 1″
		20	3—18		15′ 0″		3—30		13′ 10″		—12	+1′ 2″		
				3—41		16′ 7′		3—45		15′ 6″			—4	+1′ 1″

February, ☾	17	2—11		15′ 5″		2—30		14′ 8″		—19	+9″		
			2—32		17′ 2″		2—45		16′ 6″			—13	+8″
(New Moon,) ..... ⊙	18	2—53		15′ 8″		3—15		15′ 2″		—22	+6″		
			3—9		17′ 0″		3—30		16′ 6″			—21	+6″
	19	3—29		15′ 6″		3—45		16′ 2″		—16	—8″		
			3—49		16′ 4″		4—0		16′ 4″			—11	0
March, ...	18	2—13		16′ 0″		2—30		15′ 4″		—17	+8″		
			2—29		17′ 3″		2—45		16′ 5″			—16	+10″
(New Moon,) .... ⊙	19	2—46		16′ 6″		3—0		16′ 4″		—14	+2″		
			3—3		17′ 6″		3—15		16′ 5″			—12	+1′ 1″
	20	3—21		16′ 8″		3—30		16′ 4″		—9	+4″		
			3—38		16′ 10″		3—45		15′ 8″			—7	+1′ 2″
August, ...	27	1—12		21′ 6″		1—30		21′ 3″		—18	+3″		
			1—30		20′ 8″		1—45		21′ 0″			—15	—4′ ′
(Full Moon,) ..... ○	28	1—47		22′ 3″		2—15		21′ 8″		—28	+7″		
			2—6		21′ 4″		2—30		21′ 5″			—24	—1″
	29	2—24		22′ 4″		2—45		21′ 10″		—21	+6″		
			2—43		21′ 7″		3—0		21′ 6″			—17	+1″

From the above it may be seen that the calculated times of Tides are generally sooner than the actual fact.

And the Heights to which the water rises are generally by calculation, a little in excess of the fact.

TABLE II.

Table showing the TIMES *of the Tidal flow up and down, from the calculated Tide Table, during the Dry weather and Rains of* 1856.

Month.	Moon.	Date.	High Water.	Low Water.	High Water.	Ebb or Flow down.	Flood or Flow up.	DRY WEATHER. Time of Flow.	
			H. M.	H. M.	H. M.	H. M.	H. M.	Ebb Tide.	
								Average. Springs.	Average. Neaps.
January, ...	◐	10	3—19	11—59		8—40		8—40	7—38
				11—59	15—38		3—39	8—23	7—31
	☽	16	8—26	4—4		7—38		8—52	7—13
				4—4	8—57		4—53	8—29	7—14
	○	24	3—29	11—52		8—23		4 [34—24	4 [29—36
				11—52	15—45		3—53	8—36	7—24
								Flood Tide.	
								Average. Springs.	Average. Neaps.
	☾	31	7—54	3—25		7—31		3—39	4—53
				3—25	8—20		4—55	3—53	4—55
March, ...	◐	9	3—12	12—4		8—52		3—25	5—27
				12—4	15—29		3—25	3—44	5—29
	☽	15	8—30	3—43		7—13		4 [14—41	4 [20—44
								3—40	5—11

				3—43	9—10		5—27				
	○	23	3—15	11—44		8—29					
				11—44	15—28		3—44				
	☾	31	8—53	16—7		7—14					
(Rains)				16—7	21—36		5—29				
September, ...	☽	9	7—45	3—16		7—31					
				15—16	20—26		5—10				
	○	16	2—15	11—9		8—54					
				11—9	14—29		3—20				
	☾	23	8—19	3—54		7—35					
				15—54	21—6		5—12				
	◐	30	2—31	10—55		8—24					
				10—55	14—50		3—55				

RAINS.

Ebb Tide.

Average. Springs.	Average. Neaps.
8.54	7.31
8.24	7.35
2 [17.18]	2 [15.6]
8.39	7.33

Flood Tide.

Average. Springs.	Average. Neaps.
3.20	5.10
3.55	5.12
2 [7.15]	2 [10.22]
3 37½	5.11

It would appear from the above that there is not much difference between the Rains and Dry Seasons as to the intervals of time between High and Low Water, that is, the *times* of Flood and Ebb.

The difference of *times* of Flood and Ebb Tides at Springs and at Neaps is considerable.

(Note. Compare with Table IV which shows the results of *actual observation* during Rains of 1856.)

TABLE III.

Time of Tidal flow up and down from the calculated Table and from the Kidderpore Guage, for Jan. 1855.

NOTE.—*January is the only month for which we have the details of low water as well as high, from the Kidderpore Dock Yard Register.*

FROM KIDDERPORE DOCK GUAGE.

	Moon's Age.	Date.	Low Water.	High Water.	Low Water.	Time of Flood.	Time of Ebb.		
			H. M.	H. M.	H. M.	H. M.	H. M.		
January,.....	☽ New Moon	18	10—15	2—45		4-0			
				2—15.	10—45		8-30	H. M.	H. M.
			10—45	2—30		3-45		5 (42-45	
				2—30	11—15		8-45	Average, 8-33	8-33
		19	11—15	3—0		3-45			
				3	11—30		8-30		
			11—30	3—15		3-45		6 (22-45	
		20		3—15	11—45		8-30	Average, 3-47	3-47
			11—45	3—30		3-45			
				3—30	12—0		8-30	Total,...	12-20½
			12	3—45		3-45			
			FROM THE TIDE TABLE.		Total,...	22-45	42-45		
January,.....	☽ New Moon	18	10—14	1—58		3-44			
				1—58	10—39		8-41	H. M.	H. M.
			10—39	2—15		3-86		5 (43-37	
				2—15	10—59		8-44	8-43	8-43
		19	10—59	2—37		3-38			
				2—37	11—19		8-42		
			11—19	2—55		3-36		6 (22-12	
				2—55	11—40		8-45	3-42	3-42
		20	11—40	3—18		3-38			
				3—18	12—3		8-45	Total,...	12-25
			12—3	4—3		4-0			
					Total, ..	22-12	43-37		

TABLE IV.

Shewing Comparison of Tidal Height and Tidal flow from the calculated Tables and from actual observation by Mr. Turnbull, C. E. in the Month of August 1856.

Month.	Moon.	Date.		High Water.		Low Water.		Difference High Water.		Difference Low Water.	
				Time.	Height of Tide.	Time.	Height of Tide.	Time.	Height of Tide.	Time.	Height of Tide.
				H. M.	Ft. In.	H. M.	Ft. In.	H. M.	Ft. In.	H. M.	Ft. In.
AUGUST, ... (Neaps,)	☽	12th.	Neap Tide.	10-8	16′ 0″	5—23	9′ 6″	+ 8	+ 4″	22	0
						6—9	9′ 5″			— 21	— 1″
(Springs,)	○	18th.	Springs.	2-44	22′ 0″	11—22	8′ 0″	— 16	— 4″	— 53	— 1′ 2″
						16—41	8′ 0″			— 1 4	— 1′ 2″
		From Mr. Turnbull's observations.						Time of Flood and Ebb. From Mr. Turnbull,		From Tables.	
								Flood.	Ebb.	Flood.	Ebb.
AUGUST, ... (Neaps,)		12th.		10-0	15′ 8″	5—45	9′ 6″	H. M. 4-15	H. M. 8-30	H. M. 4-45	H. M 8-1
						6—30	9′ 6″				
(Springs,)		18th.		3-0	22′ 4″	12—15	9′ 2″	2-45	9-45	3-22	8-57
						12—45	9′ 2″				

Drainage Committee.

APPENDIX No. III.

Salt Water Lake.

The Salt Water Lake consists of a low inland basin, situated 2 miles to the East of Calcutta, traversed by a deep main Channel, which runs from Dhappa in a South-east direction towards the Mutlah, and is 106 miles in length to the Sea.

The tides from the Bay of Bengal enter this expanse through the Creeks and Channels communicating with it, and are diffused or dispersed over its surface, so that the level of the water in the Lake at flood is lower than it is in the Channel further down sea-ward, or lower in the Northern than the Southern part of the Lake.

There are many large Jheels along the coast, similar in character to the Salt Water Lake, and connected with the Sea by Salt Water Creeks or Channels, and receiving a considerable fresh water drainage along their Northern margins; and the same fact as to level holds good with all.

The variation of the water level at high and low tide is small in these Jheels, compared with that in Rivers, such as the Hooghly, where the water is restricted between well-defined banks. In the latter, the in-rushing tide being confined, it rises higher;—in the former, it is dissipated or dispersed and rises but little.

As the tide ebbs, the water is drained off and flows out through numerous branches into the main Channel or Creek, the depth of which is maintained by the scouring action thus produced.

The Salt Water Lake is traversed through its wide diffusing surface by a deep water Creek, which is navigable even for a River Steamer close up to Calcutta. Down this Channel all the retiring waters of the Lake at ebb tide pour by innumerable side Channels, and its rapidity and dimensions increase from almost perfect stagnation and dimensions given to it artificially at its North-west extremity, to a current always rapid at Bamunghatta 5 miles down, and a Channel measuring 180 feet in breadth and 20 feet in depth.

In the summer, when the Lake is—it may be said—exclusively under tidal influence, and not affected, as in the rainy season, by fresh water drainage, the variation in its level at high and low tide is considerable, at Dhappa from 2 to 3 feet, and at Bamunghatta from 4 to 5 feet. In the rainy season it is only from 1 foot to 1½ feet.

In the months of December, January, and February, when the flood tides are sluggish, the time of high water at Dhappa, which is the North-west extremity of the main Channel, is 2 hours later than in the Hooghly, and the flood tide in the

lake lasts in such circumstances nine hours, and the River is 5 feet above and 4 feet 6 inches below the Lake at high and low water respectively.

During March and April, when the tides are at their maximum, the variation in the Lake remaining about the same, but being much increased in the River, the time of high water in the latter is two hours in advance of the former, and the River is 8 feet higher at high and 6 feet lower at low water.

In the rainy months, when the Lake receives a considerable quantity of fresh water drainage along its Northern limits, and its waters are maintained at a generally higher level, the time of high water in it and in the River is nearly coincident. The general level of the Lake is about the same as the River at low and 5 to 11 feet below it at high water.

Such is the substance of Captain Prinsep's remarks on the relative levels of the River Hooghly and the Salt Water Lake, during three seasons of the year, *viz.* the cold weather, the dry months, and the rainy season.

The Committee have had some observations taken of the tide levels in the main Channel, which runs through the Salt Water Lake. These have been limited, as the Committee was only assembled in March 1856, to the dry and rainy seasons of that year and they confirm generally the remarks noted by Captain Prinsep twenty years ago as to the times of tide in the Lake and River.

Mr. Clark, in his Report, has entered the following Table.—

Height of surface in the Salt water Lake above datum, as given by

BLECHYNDEN	Highest level in the rains	9 feet.
	Lowest ditto in dry season	7 feet.
SCHALCHS	Highest level in the rains	9 feet 8 in.
	Lowest level in the dry season	8 feet 10 in.
PRINSEP ...	Mean level	7 feet 9 in.
SIMMS .	Level of Canal entering Salt Water Lake ...	10 feet 2 in.
SCHALCHS ..	Also says tide in the Lake during the dry season rises ..... but during rains it is imperceptible.	10 inches;
SIMMS ..	Highest level of Calcutta	30 feet.
	Lowest ditto	28 feet.

and deduces therefore, that the average level of the surface of the Lake is about 10 feet below that of the surface of Calcutta.

There is however now an alteration in the levels of the Salt Water Lake, for the observations lately taken for the Committee show that the highest level in the rains at Dhappa is 12·56 feet above datum, lowest level in dry season 6·78 feet ditto.

This change is attributed by Mr. Clark (*vide* page 70 of Evidence Appendix V.) to the influence of the Circular Canal, connecting the Hooghly from Chitpore with the Salt Lake at Dhappa, in which the Lock Gates at Chitpore were constructed expressly for the purpose of excluding the River tides from the Canal. This was formerly the case, but now it is the practice to admit the tide freely from the River up to the height of 15 feet on the Gauge.

The Committee concur in this opinion, but they think also, that the gradual restriction of the area of the Lake from 37 square miles, as stated by Colonel Forbes, to 18 square miles, as computed from the Revenue Survey Map of the day, must have contributed to affect the alteration in the height of the Lake tides.

The accompanying Table will show, in a tabulated form, the average water level of Captain Prinsep, reduced to the datum of Kidderpore Dock sill.

The blue lines are drawn from points which are the mean levels, besides which the extreme levels are distinguished by a separate mark + thus.

From this we glean, that Captain Prinsep gives the low water Lake level in the dry and cold seasons as 6 feet 3 inches and its high water level as 8 feet 9 inches. By notes of evidence, his extreme high water is 9 feet 3 inches.

From the Committee's observations taken at Dhappa and Tengrah, which are situated, the former at the head and the latter one mile down the main Channel of Salt Water Lake, we find that the average low water mark was + 8 and high water 11·50. This proves an increased relative rise between high and low water from 6 inches to 1 foot in excess of Captain Prinsep, and an absolute rise in both high and low tide of nearly 2 feet.

This may be accounted for by the admission of the River tides through the Circular Canal, together with the gradual restriction of the area of the Lake, and the Committee point to the fact of the change in the height of the tides which has occurred, as one of considerable importance to the drainage of Calcutta.

They observe, that a new Canal is being excavated from Dhappa to the Hooghly, and that they may expect a similar volume of the River tides to be poured eventually through it into the Lake main Channel. Likewise, the process of reclaiming the land by embanking in successive portions of the Lake is still in active operation by the proprietors of the soil, which is annually becoming of more value from the gradual extension of the Town of Calcutta in this direction, and they apprehend with reason, that still further alterations will take place in the height of the Lake tides and depth of the Channels, if the encroachments of the zemindars on the area of the Lake be not checked in good season.

They would therefore strongly recommend, that the Municipality of Calcutta should have its jurisdiction extended over the Salt Water Lake and its Channels, in order to fix within proper limits the free ingress of the River tides through the Canals and to check the further restriction of the area of the Salt Water Lake.

The Committee do not consider that any insalubrious effect is produced upon this Town by the proximity of the Salt Lake, or by its position in the direction of the prevailing South-East Wind. The air rushing in from the Sea to fill up the partial vacuum caused by the rarefaction of the heated land air, passes over the Sunderbunds, and at certain seasons becomes charged with the malaria arising from decayed vegetation; and it is this which would produce a deleterious effect on the climate of Calcutta, if it had not to come in contact first with the watery expanse of the Salt Lake, the briny surface of which in some degree clears it of its impurities.

The Committee, after personally investigating the nature of the main Channel through the Salt Lake, believe it to be well adapted for the purpose of an out-fall or receptacle for the whole drainage of Calcutta. The current in the upper portion of it has been considerably increased since the time of Captain Prinsep by the opening of the Circular Canal. At one mile East of Dhappa at the junction of the Tengrah Creek they ascertained the surface velocity to be 1½ miles per hour, and below this, the velocity is soon rapidly augmented during ebb tide, by the retiring body of water brought up during the flood and dispersed over the shallow bed of the Lake.

As in all tidal Channels, the result of the scour both ways is to produce a clear and uniformly-shaped Channel, like a Canal, with a firm bottom, without mud banks or shallows, there can be no doubt that, if the sewerage were thrown into this, it would be removed with certainty and rapidity in the tidal waters, while their salt quality *would have the effect found at Venice and elsewhere of disinfecting them and rendering them innocuous.

The point which Mr. Clark has selected for the outfall of the sewerage, *viz.* Tengrah Creek, is adopted by the Committee, provided that no further change occurs in the level of the Lake tides. Any alteration in the existing state of matters would render it necessary to seek an outlet further down the main Channel, and they record their opinion that tidal observations at Dhappa, Tengrah and Bamunghatta should be instituted to place beyond doubt the fact of any future changes.

Mr. G. A. Prinsep, in his letter dated April 1834, says that the ordinary rise and fall of tide between December and June is from 3 to 4 feet in the Canal at Balliaghatta, whereas in the River it rises and falls from 8 to 12 feet, so that as the mean level of the Lake surface corresponds nearly with that of the River, the tides of the latter cross those of the former in such way, that for about half the day they will fall into the new Canal at Chitpore, and for the other half the Canal will discharge itself into the River where the Gates are open.

---

* Specific Gravity of	Saturated Brine	... ...	1·216
,, ,,	of the Ocean	... ...	1·028
,, ,,	Salt Lake formerly	... ...	1·016
,, ,,	,, ,,	.. ..	1·017
,, ,,	,, ,,	... ...	1·015

When the Chitpore Gates were open, the Specific Gravity at Dhappa was 1·003 and 1·005.

Drainage Committee.

APPENDIX No. IV.

WATER SUPPLY.

THE supply of water now in use in Calcutta, whether for drinking or for drainage and other purposes, is obtained from the following sources :—

1. From the *River*.
2. From *Tanks*.
3. From *Wells*.
4. From *Rain-water* stored up.

It is proposed to consider, 1st, the *Quality* of these waters.

2nd. The *Quantity* of them which is obtained and brought into use ; and,

3rd. How any change for the better in the supply might be effected, or what this supply might be.

Quality of the River Water.

The Quality of the water of the River Hooghly is excellent ; except during a short portion of the dry weather, about the Equinox, when the tides running up with considerable force bring sea water with them. It is then occasionally slightly brackish, but for short intervals only. Even in the hot weather it is brackish only for very short intervals, nor is the brackishness at any time such as to require the intermission of the working of the Chandpal Engine, nor of sufficient importance to enter into the analysis of the water. which as made by Mr. H. Piddington, will be found in the sequel.

From the River, ships take in their supply for long sea voyages, and all Hindoos prefer using it for drinking purposes, if their occupations and means allow of their sending for it.

It is distributed through a considerable part of the town by the Steam Engine erected at Chandpal ghat. It is supplied to some of the largest and best city Tanks, including that in Tank-square, said to contain the best water in Calcutta, and although liable from the method in which this is done to additional impurities, yet when allowed time to settle, no water can be better or more wholesome than the water of the large tanks in Calcutta supplied from the River.

The impure matters which pass, or are thrown into the River, are numerous.

The Drains of great part of the city, and all those along the River bank, run into it.

The night soil of the city is collected and thrown in by the Tola Mehters under Municipal regulations.

The dry rubbish and refuse of the roads, dwellings, and compounds, is thrown over the Strand or River bank in large quantities.

The bodies of the cattle which die in the city are (after their hides are removed) thrown into the River from the Skinning ghat to the average number of 100 daily; and also the dogs killed by order of the Commissioners, which amount to from 10 to 20,000 annually.

Commissioners' Report, 1st January, 1856, p. 37.

All the dead bodies of the Hindoo inhabitants, with or without cremation, are also carried off by it from the burning and other ghats and from other parts of the River bank.

Analyses of the water have been made at different times by Mr. H. Piddington, Curator of the Museum of Economic Geology, an abstract of which, is here subjoined.

These analyses have reference chiefly to the amount of the silt, and to the Lime in the water, which is one of its chief ingredients. The brackishness or the quantity of salt in it, is not found by Mr. H. Piddington to be of sufficient amount to be worth testing for. The quantity of decomposing animal matter it holds in suspension, and the aluminous as distinguished from the silicious particles, might be worth separating in future analyses.

The following extracted from the Journal of the Asiatic Society, is the result of Mr. Piddington's Analyses.

Journal Asiatic Society, No. 254.

TABLE 1st.

Tabular Statement of the amount of Silt held in suspension by the Surface water of the Hooghly, at Calcutta, for each month, from April 1854 to March 1855.

Number.	Date.	Quantity of water.	Solid earthy matter.	Carbonate of lime in water.	Total of solid matter, silt and lime.	Lime found in the solid matter only.
	1854.	*Oz.*	*Grs. Silt.*	*Grs.*	*Grs.*	
1	3rd April, ...	22·70	0·50	3·92	4·42	
2	4th May, ...	21·80	0·60	1·52	2·12	
3	5th June, ...	30·00	0·60	2 61	3 21	Trace.
4	4th July, ...	23·75	4·25	·58	4·83	
5	5th August, ...	23·80	11·75	·32	12·07	
6	1st September, ...	23·60	4·00	1·17	5·17	Trace.
7	1st October, ...	23·20	2·88	1·44	4·32	
8	4th November, ...	22·00	1·20	·59	1·79	
9	1st December, ...	25·00	4·20	1·35	5·55	
	1855.					
10	10th January, ...	25·50	3·65	·47	4·12	
11	3rd February, ...	24·00	5·25	1·95	7·20	
12	8th March, ...	24·30	·75	1·75	2·50	
	Totals...	289·65	39 63	17·67	57·30	
	Means, ...	24·14	3·30	1·47*	4·77	

* Less Magnesia ·254 per month.

TABLE 2ND.

Tabular Statement of the amount of Silt held in suspension at a mean depth of 3 fathoms by the water of the Hooghly, at Calcutta, for each month, from April 1854 to March 1855.

No.	Date.	Quantity of water.	Solid earthy matter (silt.)	Carbonate of lime in water.	Total of solid matter, silt and lime.	Lime in the solid matter only.
	1854.	*Oz.*	*Grs.*	*Grs.*	*Grs.*	*Grs.*
1	3rd April, ...	22·60	8 70	1·60	10·30	0·15
2	4th May, ...	23·80	6 25	1·00	7·25	Trace.
3	5th June, ...	21·20	1·30	3·12	4·42	0 00
4	4th July, ...	22·50	6·50	1·00	7·50	0·00
5	7th August, ...	23·50	13·30	0 08	13·38	Trace.
6	1st September, ...	24 50	7·62	1·10	8·72	Trace.
7	1st October, ...	26 00	7·00	0·72	7·72	0·00
8	4th November, ...	26·00	2 60	0·89	3·49	0·00
9	1st December, ...	22·50	1·60	0·75	2·35	0·00
	1855.					
10	2nd January, ...	24·00	2·36	2·60	4·96	0·00
11	3rd February, ...	23·80	8·50	1·18	9·68	1·00
12	8th March,...	24·00	6·50	1·76	8·26	0 00
	Totals,...	284·40	72·23	15·80	88·03	1·15
	Means, ...	23 70	6 02	1·32*	7·34	0·09

When examined for silt and carbonate of lime, the results were found to be, for the same measure of water :—

	Solid matter.	Carbonate of lime.
In Mid Channel,.....	1·36	1·52
At 20 yards from the shore, ...	0·75	2·00

Hence we see, that the silt is less in shore, though the proportion of lime is twenty-five per cent. more than in mid-stream.

* Less Magnesia 0·312 per month.

Mr. Piddington thinks it desirable to take *for the present* the mean between his former observations and analyses in the year 1842 and those of the year 1856.

The mean proposed would be as follows :—

	Water Oz.	Solid earthy matter silt.	Carbonate lime in water.	Total solid (silt and lime)
1842, ... Mean, ...	25·33	6·04	7·95	13·99
1854-55, at 3 feet depth, ... Mean, ...	23·70	6·02	1·32	7 34
	49·03	12·06	9·27	21·33
Mean of both series, ...	24·51	6·03	4·63	10·66

" Now with the same data then as in my former paper," Mr. Piddington writes " *i. e.* 1·73296 cubic inches to the (Apothecary's) ounce of water, the above average quantity of water, 24·51 oz. will be equal to 42·47385 cubic inches ; which, to save decimals we will call 42·48 cubic inches of water, containing 6·03 grs. of silt and 4·63 grs. of lime, which for a cubic foot of water will give 433·63 grs. or nearly $\frac{9}{10}$ths (nine-tenths) of an ounce for the whole solid contents of the cubic foot of water."

" The proportion of carbonate of lime to the total of solid matter is also less, for in 1842 of the 13·99 grains of solid matter, 7·95 were carbonate of lime, which proportion should give 6·06 for the 10·66 grains of solid matter of 1854-55, whereas we find it to be 4·63 only, or one-third less."

"Again, in 1842, the four months of March, April, May and June were those in which the largest amount of sediment was brought down, whereas in 1854-55, the four months of July, August, September and October, give the largest amount of solid matter ; which is, for the whole year, as 7·34 only, to 13·99 in 1842, and for the four heaviest months as follows—

	In 1842.	In 1854-55.
"Average quantity	By former paper	At 3 ft. depth
of Water in the four heaviest months.	25·50 oz. or 44·19 cubic inches.	24·12 oz. or 41·80 cubic in.
Of Silt,	24·77 grs.	7·83
Of Carbonate lime,	13·56 grs.	0·72

	In 1842.	In 1854-55.
"Average quantity of silt in each cubic foot of water,	By former paper 1678·92 grs.	At 3 ft. depth 353·46 grs.

which last (*i. e.* the 353·46 grs.) are equal to 0·8366 cubic inches or $\frac{1}{2072}$ (one, two thousand and seventy-second part) of its bulk, of which however only about $\frac{1}{12}$th is carbonate of lime."

"The cubic inch of the dry solid silt, as deposited, I shewed in my former paper to weigh about 424 grains. To this our present result, 433·63 grains to a cubic foot of water, is so near an approach, that we may take it as the average, and in round numbers say, for facility of recollection, that every cubic foot of water contains a cubic inch of silt, or more exactly in fractions, not $\frac{1}{1333}$ (one, thirteen hundred and thirty-third) part of its bulk of silt, as before found for 1842, but $\frac{1}{1728}$th (one, seventeen hundred and twenty-eighth part.) This is still, however, an enormous proportion when we recollect the mass of water discharged by the Hooghly alone, which Mr. Bedford, the late River Surveyor, by careful sectional measurement calculates "at 500,000 cubic feet per second at Moyapore, thirteen miles below Calcutta."

Mr. Everest whose observations on the amount of silt in the water of the River Ganges at Benares were taken and published in the Asiatic Society's Journal in the year 1831, gives as the amount of sediment:—

In the Rains, $\frac{1}{856}$

In the cold months, $\frac{1}{3076}$

In the hot weather, $\frac{1}{7654}$.

Colonel Forbes made an analysis which agreed with the first of the above by Mr. Everest, *viz.*, $\frac{1}{856}$. This is about 2 cubic inches of sediment in a cubic foot of water.

Municipal Committee's Report.

Mr. Ellet in his work on the Mississippi takes the amount of sediment in a flood of that river to be $\frac{1}{1800}$.

And Mr. Riddell, of New York, gives the mean result of his experiments on the same river as $\frac{1}{3000}$.

Major Kennedy assumes the proportion of 2 cubic inches of silt in a cubic foot of the water of the Ganges.

Captain C. B. Young found in the month of January 1855, that 14 ozs. of River-water taken off Calcutta, contained 4 grains of sediment. This is equivalent to $\frac{2}{3}$ of a cubic inch of silt per cubic foot of water, or $\frac{1}{2575}$ and is somewhat more than the proportion found by Mr. Everest, in the same month of the year at Benares.

It may be added that an analysis of the Thames water by Mr. Kerrison in 1834, gives $\frac{1}{3217}$ of solid matter, and that the Seine is said to contain only $\frac{1}{20000}$,

None of the analyses of the Hooghly or Ganges water discriminate between the aluminous and silicious parts of the sediment deposited. There is nevertheless, a decided difference in their rate or time of precipitation in the water, and there may be important consequences attached to this fact not as yet perhaps fully understood, which may tend to neutralize the noxious effects of the putrefaction and decomposition of the large quantities of organic matter carried off by it, and to render the water, what it undoubtedly becomes after being allowed time to subside, pleasant and palatable for drinking purposes.

Mr. Piddington states that he found "the silt of the surface water of the Hooghly, in the month of November, took exactly 9 days to sink through one foot of water in a cylindrical glass vessel."

He also remarks, that the water from Lloyd's channel near Saugor, where it is of course much diluted, appeared to have settled into 2 layers or strata of silt. The lower a fine micaceous sand, and the upper, a black fetid mud, strongly impregnated with sulphuretted hydrogen.

Report on Water Supply to Bombay.

It is a well known fact that the Hooghly, Thames, and other River waters, after becoming on first keeping fetid and foul smelling, do, after being allowed a few days to settle, purify themselves, and become sweet and palatable.

The following remarks extracted from Mr. Conybeare's interesting report, will shew the value and effect of clay or alumina, in producing purification of foul waters :—

(*Para.* 131.) "After filtration through vegetable charcoal the water entirely lost its green hue, but possessed a certain degree of opacity, and, examined with the microscope, the smaller animalcules were to be detected in great numbers. Passed through animal charcoal, the water came out bright and transparent, without colour or opacity, and no animalcules could be discovered in it. Through loam, the water was still preceptibly green, and contained the animalcules in great abundance ; filtered through mild and strong clays, the water was nearly as clear and bright as through the animal charcoal, without trace of infusoria. By filtration through clay and animal charcoal, the infusoria were so far removed that none could be detected by means of the microscope."

(*Para.* 152.) "Professor Way further states, that by filtration of the water of Rivers containing salts giving hardness, and different animal and vegetable matters in solution through a bed of soil, he removed all these (with the exception of those salts of lime before enumerated, and such other salts of lime as were formed from alkaline sulphates, muriates and nitrates) and produced comparatively pure water ; and that in this way he reduced Thames water of 15 degrees of hardness (15 grains of carbonate of lime in the gallon) to less than 2 degrees of hardness, and rendered it soft and pure."

(*Para.* 153.) "It will be remarked in these experiments, that sand is by no means the most powerful filtering medium in proportion to its bulk, and that in many of the foregoing experiments, results were obtained with clay and animal charcoal filters, far more perfect than could be produced by an equal thickness of sand; but it must be remembered that these experiments were tried with a thickness of only 9 inches of sand, and that in filters of the most recent construction for purifying the water supplied to towns, an aggregate thickness of 12 feet of filtering media is provided."

(*Para.* 159.) "Clay, though experimentally equal to animal charcoal, is found inconvenient to use, as it is liable to muddy the water that passes through it. Burnt clay is however free from the objection, and stated to be otherwise equally efficacious. It is probable the amygdaloid owes its efficiency to its similarity to burnt clay."

Quality of the Tank Water.

The Tank water of Calcutta is that usually drunk by all classes, as it is more readily obtainable; but when they can do so, the Natives prefer sending to the River for their drinking water.

That this water is pure and good when the Tanks are filled during the rainy season, there can be no doubt. As it becomes exhausted however by daily use and by evaporation during the dry months, it becomes in many cases, particularly in the smaller tanks, far otherwise.

Vegetation increases and animalculæ abound. The former has to be removed by hand. In the principal Tanks this is done at intervals by the Municipal authorities. The latter are removed when the water is used for cooking and drinking, by means of purification with alum or by filtering in various ways.

On this subject Mr. Conybeare says (para. 221)—"I believe that the present rapid contamination of the tank water, is solely due to its exposure in shallow stagnant reservoirs, to the heat and light of a tropical sun, and to its absorption of the gaseous impurities and floating organic particles with which the air of filthy and ill-ventilated towns is always contaminated. The rapidity with which rain water stored in open tanks becomes contaminated in this town is extraordinary. An establishment is kept up for removing what is called "vegetation" from the tanks; during the late monsoon the public tanks were covered with such vegetation, and it was accordingly skimmed off. The form of this matter was that of floating green slime; from its bad smell I suspected that it was not of vegetable origin, and on examining it with a powerful microscope, I found it to consist of an aggregation of myriads of a little green animalcule called the "Monas grandis." After keeping it in a glass of water two days, the water became a deep opaque purple, and extremely offensive even at a considerable distance."

The quality of the water of the large and deep tanks of Calcutta is not however

so bad as might be supposed. When it is filtered or purified, as before described, it becomes palatable and wholesome.

Doubtless this is in part owing to the care taken to prevent slimy weeds spreading over the surface, which would prevent its being agitated and purified by the wind.

The balance kept up by animal life in them (and the lease of the fishing is sufficient to form an item in the receipts of the Commissioners) may also contribute to this end.

Dependent as the natives are on their Tanks for water, it is extraordinary that they should not be more particular in keeping them clean, by preventing their margins and banks from being defiled. The contrary was observed by Mr. Simms in Calcutta, and is mentioned in his Report, page 74, and is also mentioned by Mr. J. Prinsep, as being the case at Benares, in these words ; " the inhabitants invariably resorting to fields, and the beds and borders of Tanks."

Quality of the Well Water.

The quality of the well water is universally brackish throughout Calcutta, and hence the existence of the great number of Tanks in which rain water, as preferable, may be preserved.

The well water is much used for all other purposes, except drinking and cooking, but even for the latter, occasionally.

For bathing, washing of all sorts, watering and cleansing, it is much in request.

It rises in the rains to 10 feet and much less from the ground surface, and in the dry weather is seldom more than 12 feet below it.

The Boring operations in Calcutta at various times, of which the following from the Asiatic Society's Journal, Vol. II. (1833) is a compendious record, have at all times proved fruitless in discovering any springs of water.

" The principal experiments on record connected with the operation of boring for water in Calcutta, are those conducted under Colonel Garstin, Chief Engineer, from 1805 to 1820, and those made under the Superintendence of Dr. Strong, Mr. J. Kyd, and Mr. D. Ross in 1829 to 1833.* The following is a list of their localities, and of the depths respectively attained."

" The geological question of the probability of finding a spring is by no means solved by the result of these numerous experiments. The knowledge which they afford us of the nature of the Calcutta alluvium may be summed up in a few words. After penetrating through the artificial soil of the surface, a light blue or grey coloured sandy clay occurs, becoming gradually darker as we descend, from impregnation with decayed vegetable matter, until it passes into a stratum of black peat, about two feet in thickness, at a depth in Fort William of 50 feet below the surface. In excavating the circular canal, the same stratum of peat occurred from 25 to 30

---

* Vide Gleanings of Science Vol. 1, page 114 and 167, Vol. III, pages 124 and 422, &c. ; also Asiatic Researches for 1814.

feet, and in the Entally canal, it lay just below the bed, or nine feet below the average level of the Salt-water lake."

The Borings in Fort William, at a later date, in 1833, when a depth of 481 feet was reached, proved equally unavailing. The water in the bore stood at the same height throughout, *viz.*, of 10 or 12 feet from the surface, according to the season, but no spring was reached.

The supply to the Calcutta wells is drawn from the upper alluvial bed, which lies above the clay and peat strata, occurring at from 10 to 30 and 50 feet below the surface.

No.	Date.	Superintendent	Place.	Depth	Cause of failure.
				Feet.	
1	1804 Dec.	Col. Garstin,	Well near Powder Magazine, ...	75	
2	1805 Aug.	Ditto	S. W. of Art. Barrack, ...	119	Auger broke.
3	„ Sep.	Ditto	S. E. of Regt. Parade,	55	Ditto.
4	„ Oct.	Ditto	S. E. of Eur. Barrack, ...	59	Ditto.
5	„ Nov.	Ditto	S. W. of Art. Parade,	80	Ditto.
6	„ Dec.	Ditto	Ditto, ...	127	Ditto.
7	1806 Feb.	Ditto	Ditto, ...	94	Ditto.
8	„ March	Ditto	Ditto, ...	124	Earth fell in.
9	„ April	Ditto	Same operation resumed, ...	127	Auger broke.
10	1814 May	Ditto	S. E. of Art. Parade,	140	Suspended by rain.
11	„ Nov.	Ditto	The same renewed,...	136	Auger broke.
12	1819 May	Ditto	On Art. Parade, ...	130	Ditto.
13	1820 April	Ditto	Ditto, ...	122½	Ditto.
14	„ May	Ditto	Near Triangular Barrack, ...	128	Earth fell in.
15	1815	Mr. Jones	Found a spring in red sand at, ...	70	
16	1826-8	Dr. Strong	Bored in the Circular canal to, ...	70	Water rose.
17	„	„	Also made several borings in the S. W. lake to, ...	40	Through similar strata.
18	„	Dr Strong	Near the Circular Road, ...	70	Hard kunkur.
19	„	Ditto	At Rasapugla, ...	70	Sand fell in.
20	1830	Strong, Ross, and Kyd	Near the Fort Church,	176	Shaft injured.
21	1832	Ditto	Near St. George's Gate, ...	164	Sand fell in.
22	1833	Ditto	Ditto, ...	170	Auger broke.
23	1832	Dr. Strong	Under the Lock Gate, Chitpore ...	70	Water sprang up.

The Rain water which annually falls in the rainy season, is stored up by many persons in Calcutta, for the purpose of drinking. As being free from the saline, organic and animal impurities which characterize the well, tank, and river waters—it is deemed highly conducive and by some absolutely essential to continued health.

Quality of the Rain Water.

It is caught in large gumlas or vessels, either from the drain spouts of any convenient flat pucka roof, which has been previously swept clean, or by extending sheets, and collecting the contents in earthen vessels placed below them.

In a tropical climate where it is impossible to exclude animal life from every corner of our dwellings, this water, is of course, apt to generate organic life after a time. It is found, however, that it is sufficient in order to prevent this, to plunge at intervals an iron heated red hot into the vessel containing the water. This being done, and the vessel always kept carefully covered in, no purer drinking water can be had, although it is wanting in the sparkle and probably in the amount of oxygen, which exposed and agitated, or good spring water contains.

The Quantity of River water supplied to the city of Calcutta can be estimated from the work of the Chandpal Ghat Engine, which is at present the only artificial means or pump used for raising it to the land level.

Quantity of River Water.

A considerable amount is drawn by the people themselves in their drinking vessels and is sold by bheesties and water carriers at the rate usually of 1 pice for a mussuck which holds about 9 gallons.

The Chandpal Engine is of 20 H. P. and lifts the River water from a well by two pumps whose cylinders are of 27¼ inches diameter, and stroke of the piston 27 inches.

It works throughout the year, except during the rains. The following is a return of its work given by Mr. Simms in his report. It is for the year 1849-50.

P. 75, Simms' Report.

Since then it has been made to work for a longer time each day, and it now pumps for 21 hours out of the 24. It now therefore often raises from 80 to 90,000 tons of water a week, instead of 50 to 60,000 as at the time of Mr. Simms' return.

Statement of the Quantity of Water pumped from the River Hooghly by the Steam Engine near Chandpal Ghat into the Town Aqueducts, during the watering season of 1849-1850.*

Monthly	Number of hours the Engine worked.			Number of strokes made by Engine.	Number of gallons discharged into Aqueducts.		
	H.	M.	S.		Gallons.	Qts.	Pt.
November 1849, ...	351	39	$3\frac{1}{3}$	3,79,783$\frac{5}{7}$	56,834.558	2	1
December „	379	0	$36\frac{2}{3}$	4,09,331$\frac{1}{7}$	51,256,325	2	1
January 1850, ...	373	10	$56\frac{2}{3}$	4,03,037$\frac{4}{7}$	60,314,472	2	0
February „	345	36	$56\frac{2}{3}$	2,73,265	55,859,034	1	1
March „	446	14	$23\frac{1}{3}$	4,81,939$\frac{4}{7}$	72,122,162	3	0
April „	480	38	20	5,19,090$\frac{1}{7}$	77,681,738	2	0
May „	495	20	20	5,34,966$\frac{2}{7}$	80,057,600	1	0
June. „	241	26	$3\frac{1}{3}$	2,60,749$\frac{4}{7}$	39,021,143	3	0
	3,113	6	40	33,62,163	503,147,036	1	1
Add the amount of quarts contained in the remainder of the different sums, ...					0	2	0
Total, gallons, ...					503,147,036	3	1

This water is lifted a height averaging from 20 to near 30 feet, according to the state of the tide, and is poured into a reservoir measuring 140 × 36, (average breadth) × 5′ 6″ deep, in which it deposits the heavier particles of silt with which it is loaded, and thence passes into a larger reservoir, divided into two portions by a cross wall, measuring 190 × 80 feet × 6 feet deep.

From this it flows into the city aqueducts, which are open masonry channels, and in some cases doubled, or one alongside another, when a larger supply is required.

Owing to the small size of the reservoirs, and the great demand for the water, the process of settling is very imperfectly performed. Nevertheless, the single reservoir into which the water all passes at first from the pump, becomes more than half full of mud by the end of the season, that is the commencement of the rains; when the engine being then stopped, the mud is removed and the reservoir cleaned out.

* The original cost of Engine including buildings, was about Rupees 40,000. The yearly cost of working it is Rupees 5,500, and of repairing from 8 to 500.

From the reservoirs the water passes into the open aqueducts, which are about 15 miles in length in that part of the city in the vicinity of the engine, and from them it is removed for use by hand whenever required, or run into those tanks which are connected with it, whenever their contents fall low.

Where the aqueduct leaves the reservoir it is 2′ 3″ above the road level. Its height gradually diminishes with its fall as it passes onwards, till in many places it is on the ground level. The dimensions of the channel are 1′ 6″ broad × 2′ 6″ deep at the commencement.

Some of the most remote of the aqueducts are however very imperfectly supplied, owing to their distance from the engine; to the difficulty of constructing them with an exact and efficient fall; to the friction the water encounters in passing through the numerous inverted syphons which lead it under roads, doorways, &c., and detract from its velocity; and to the abstraction of it on its way, which leaves but little eventually for the extremities.

Some of the water is also used for the purpose of cleansing and flushing drains. Iron Trap valves in the side of the aqueduct when opened, discharge such a stream of water as may be sufficient for the purpose into the adjoining drain, and when closed by hand again, shut it off.

In the parts of the city through which the aqueduct passes, the inhabitants may be seen, particularly in the heat of the day in great numbers collected by its side, and using it for bathing and washing themselves and their clothes. Some also use it for drinking.

The carelessness with which the aqueduct water is drawn and used by many in washing and bathing, causes much of it to flow back into the channel, and this when it is considered that some of the persons using it may be diseased, is very objectionable.

Besides this, the nature of construction of the aqueducts themselves is open to objection, from the space they occupy, and the dampness and injury to adjacent buildings from the leakage which unavoidably takes place from them.

This advantage they have, that the silt deposited by the water can be easily removed.

Quantity of Tank Water.

By the end of the rainy season or indeed before that time, all the tanks in Calcutta are full to the brim.

The number of Tanks in Calcutta is given by Mr. Simms as 1043. This excludes of course innumerable small ones which might more properly be called pools or puddles, and which are of a very fetid and foul description.

The soil obtained to raise the floor of a Bengallee's hut is excavated in its immediate neighbourhood. Every Bengallee endeavours to raise his floor if possible, so as to exclude rain water and damp, and the consequence is, that every hut or collection of huts has close to it a puddle or a pool or a small tank, so called, which collects and retains the drainage and the rain water of the season.

'In this, until it becomes absolutely too filthy, the inhabitants bathe and wash their cooking vessels, their clothes, &c.

In the green color, and scum which cover these pools, they seem to perceive nothing objectionable, or else they are too indolent to go further than their very doors for the quantity of water requisite for the washing purposes mentioned.

Of the quality of drinking water all natives of India may be said to be good judges. It is their sole beverage and they are very discriminative of its quality. All would fetch it daily from the River if possible, and there are few who do not go for what they require for this purpose, to the best tank in the neighbourhood. If their caste allow it, and they are able to afford it, they purchase it from the bheesties.

It cannot be doubted therefore, that if there were a sufficient quantity of clean water available, it would eagerly be used, at least for all washing and bathing purposes, even though that for drinking continued to be drawn, personally and by hand from the river or favorite tank.

As regards the effect on the health from these pestilent puddles or tanks, the testimony of all medical men from Dr. Martin downwards is unanimous, in declaring them to be most deleterious and the cause of numerous diseases.

It should be known, especially in this city which is of some note in the annals of cholera, that it has been found that the active operation of cholera is exactly proportional to the level or depression of the site. The lower a site the more active is cholera.

On this point we quote from Mr. Conybeare's report, the opinion of the General Board of Health supported by the testimony of Dr. Angus Smith; and also the valuable opinions of Dr. Simon, from his reports on the city of London from the years 1848 to 1853 addressed to the Commissioners of Sewers.

The Board of Health state that "on taking wide averages the prevalence of epidemic disease is found to be in proportion to the state of drainage, and to the excess of damp, where other conditions are similar."

Mr. Conybeare's Report, note to para. 64.

"On dividing the metropolis into two great districts, the highest, and the lowest, in relation to the Trinity High Water mark, we find that whilst in the highest districts, at an average level of 54 feet above high water mark, the proportion of deaths from fever was in 1838, 1 in 525; in the lower districts at an average level of 11 feet only above high water mark, the deaths from fever were 1 in 255. In 1832, the deaths from cholera in the higher districts were only 1 in 551; in the low lying districts they were 1 in 200. In 1849, in the higher districts, the deaths from cholera were 1 in 347; in the lower districts 1 in 118."

"The last most severe visitation observed a close relation to the differences of drainage level, for whilst during the preceding attacks, the visitation was severest

in some of the intermediate districts, on dividing the whole of the metropolis into 3 districts, the highest averaging 63 feet above high water mark, the intermediate averaging 30 feet, and the lowest averaging 4 feet, we find that the deaths were in the highest 1 in 346, in the intermediate 1 in 156, and in the lowest 1 in 93."

The following extracts from Mr. Simon's fifth Annual Report on the sanitary condition of the city of London addressed to the Commissioners of Sewers, will show briefly, but in striking language, not only his own, but the opinion of all medical men who have written on the subject; one connected so immediately with the state of Calcutta.

Mr. Simon's 5th Annual Report, page 224.

"The low level, in itself, or rather in respect of the watery dampness which it implies, is not enough to localise the pestilence. To be afloat at sea might be the safest lodging."

"This second condition impends wherever there dwells at such levels a certain density of population; it mainly varies with the degree in which that dense population lives in the atmosphere of its own excrements and refuse. In this respect I cannot refrain from saying, that the giant error of London is its present system of drainage. Probably in considerable parts of the metropolitan area, house drainage is extensively absent; probably in considerable parts the sewers, from the nature of their construction, are very doubtful advantages to the districts they traverse; but the evil before all others to which I attach importance in relation to the present subject, is that habitual empoisonment of soil and air which is inseparable from our tidal drainage. From this influence, I doubt not, a large proportion of the metropolis has derived its liability to cholera. A moment's reflection is sufficient to show the immense distribution of putrefactive dampness which belongs to this vicious system. There is implied in it that the entire excrementation of the metropolis (with the exception of such as not less poisonously, lies pent beneath houses) shall sooner or later be mingled in the stream of the river, there to be rolled backward and forward amid the population; that, at low water, for many hours, this material shall be trickling over broad belts of spongy bank which then dry their contaminated mud in the sunshine, exhaling fœtor and poison; that at high water for many hours, it shall be retained or driven back within all low level sewers and house drains, soaking far and wide into the soil, or leaving putrescent deposit along miles of underground brickwork, as on a deeper pavement. Sewers which, under better circumstances should be benefactions and appliances for health in their several districts, are thus rendered inevitable sources of evil. During a large proportion of their time they are occupied in retaining or redistributing that which it is their office to remove. They furnish chambers for an immense fœcal evaporation; at every breeze which strikes against their open mouths, at every tide which encroaches on their inward space, their gases are breathed into the upper air, wherever outlets exist, into houses, foot-paths, and carriage-ways."

"To some individual house-holder, dwelling at a high level, all concern in the subject may seem to terminate with the defluxion of his own sewage. So that his own pipes remain clear, little cares he for the ultimate out-fall of his nuisance; perhaps, if he knew better, he would care more. His gift returns to him with increase. Down in the valley, whither his refuse runs, converge innumerable kindred contributions; from city and suburb, from an area of a hundred square miles covered by a quarter of a million of houses, with their unprecedented throng of metropolitan life, there pours into that single channel every conceivable excrement, out-scouring, garbage and refuse, from man and beast, street and slum, shamble and factory, market and hospital. From the polluted bosom of the river, steam up incessantly, though unseen, the vapours of a retributive poison; densest and most destructive, no doubt, along the sodden banks and stinking sewers of lowest level; but spreading over miles of land. Sometimes rolled high by wind, sometimes blended low with mist; and baneful, even to their margin that curls over distant fields. For not alone in Rotherhithe and Newington, not alone along the Effra or the Fleet, are traced the evils of the great miasm. The deepest shadows of the cloud lie here, but its out-skirts darken the distance. A fever hardly to be accounted for, an infantile sickness of undue malignity, a doctor's injunction for change of air may at times suggest to the dweller in our healthiest suburbs, that while draining his refuse to the Thames, he receives for requital some partial workings of the gigantic poison-bed which he has contributed to maintain."

"In describing to you the local affinities of cholera, I have intimated that, in its preference for our low metropolitan levels, it selects these soils specifically in respect of their being damp with organic putrefaction."

Ditto ditto, page 230 et seq.

"Let a district be defective in house drainage, so that its soil is excavated by cesspools, and sodden by their soakage; let its sewers be ill-constructed and foul, so that offensive gases are ventilated into the immediate breathing-air of the inhabitants; let its pavement be absent or imperfect, scattered with refuse and puddled with water. You will easily conceive that, under these circumstances, all distinctions of level are merged in the strong identity of filth; and whatever diseases belong to putrefactive dampness of soil, will strike here as readily as on the low lying mud-banks of the river."

"In the remarks which I have made on the local distribution of cholera, you will have observed that I dwell particularly on one class of sanitary evils as concerned in its production; on that class, namely, which consists in the retention and soakage of organic refuse, on that class which has its appointed antidote in a system of inodorous drainage, of uninterrupted pavement, of complete and punctual scavenage."

"On this I particularly insist, because I believe that here is the very atmosphere, without which cholera would cease."

"But, deeply impressed as I am with the importance of these considerations, I

esteem it of higher consequence, if measures are ever to be taken for an effective prevention of the disease, that the principle of its specific causation should be steadfastly kept in view. What may be the exact chemistry of this process, I do not pretend to say: urging only, that in all human probability, the poison arises in specific changes impressed by some migratory agent upon certain refuse elements of life."

"Whatever in its nature it may be, this at least we know of its operation. Past millions of scattered population it moves innocuous. Through the unpolluted atmosphere of cleanly districts, it migrates silently, without a blow: that which it can kindle into poison, lies not there. To the foul, damp breath of low lying cities, it comes like a spark to powder. Here is contained that which it can swiftly make destructive. Soaked into soil, stagnant in water, griming the pavement, tainting the air, the slow rottenness of unremoved excrement, to which the first contact of the foreign ferment brings the occasion of changing into new and more deadly combinations."

To return to the tanks. Mr. Simms divides the number of 1,043 tanks which exist within the municipal limits, into 13 public in the city, 20 also public on the Maidan, and 1,010 private.

The total area of these is $\frac{1}{25}$ part of the area of the whole city. That is in other words, that in every quarter of a square mile of the city, there is tank space or water, equal to 175 yards square or 525 feet square. This is the area of the water at the average depth.

Several private tanks belonging to natives, as well as some of the public tanks are filled up from the city aqueducts when their water level sinks low, and many more would be glad thus to derive a certain supply of wholesome water if circumstances admitted of it. No objection exists to water thus supplied, but on the contrary, that drawn from these tanks is preferred to the water of other tanks.

As regards the amount of river water supplied to the city through the medium of tanks, into which it can be pumped by engine power, it is evident that the number of tanks being so great, the supply is only limited by the extent of engine power employed and the cost of constructing the connecting aqueducts or pipes.

Under these circumstances it is perhaps unnecessary to consider the amount of diminution in the contents of tanks by evaporation, absorption, and abstraction, for although considerable inconvenience is no doubt felt by the poorer classes towards the close of the hot weather in some localities, and although they often have at some expense to purchase water, yet this is confined to those who are distant from both the river and from the good tanks which are supplied as above mentioned. The remedy is simple and obvious, and neither unattainable nor it is hoped far distant.

The Dhurrumtolla tank for instance which is much used, would run dry in the hot season if it were not replenished by the engine two or three times.

Mr. Conybeare takes the Bombay evaporation at two-thirds that of Calcutta, which

in the Asiatic Society's Journal is calculated at 15 feet per annum. That of the neighbourhood of London is 5 feet per annum, as ascertained at the Greenwich observatory.

Mr. Conybeare considers a depth of 12 to 15 feet necessary to prevent the growth of water plants. The usual depth of tanks in Calcutta is 18 feet, and the annual diminution of those whose contents are not renewed by the aqueduct, can only be conjecturally stated at from 8 to 10 feet.

This would allow for the eight dry months of the year about $\frac{1}{2}$ an inch per diem for all the items of absorption, evaporation and abstraction. But in those tanks which are much used and can be replenished from the aqueduct, Mr. Rowe states the daily diminution to be as much as an average of 1 inch.

Lieutenant O'Connell of the Madras Engineers in his report on the water supply of Madras, calculates from practical data of observation, the daily evaporation of a tank at ·29 of an inch per diem, or nearly $\frac{3}{10}$ inch. Absorption he also calculates at the same in a new tank. The two together amount to $\frac{6}{10}$ but eventually in an old or self-puddled tank, he thinks both together would in a few years be reduced to $\frac{3}{10}$ on an average.

If on such rough data it be permitted to make a calculation, it will be seen that assuming the tank area at $\frac{1}{25}$, the whole area of Calcutta as before stated, and the consumption at $\frac{3}{4}$ of an inch, the amount of tank water per head of a population of 450,000 used daily, would be 7 gallons.

The extent of the dry months is however scarcely so much as eight full months in Calcutta, and a renewed supply is always obtained to some extent by the gales from the equinox to May. Some modification in the above would therefore take place. It might probably be found by actual trial to be between $\frac{1}{2}$ and $\frac{3}{4}$ of an inch per diem.

It is matter for surprise, considering the blessing of water in this climate, the innumerable purposes to which it can be supplied with profit and pleasure, and the boon it is to all classes of the community, that none of the opulent Natives of this city have ever endeavored to establish, with the consent of Government, any artificial means of raising and supplying it from the inexhaustible source of the River which runs at hand.

A simple machine invented and used by Mr. Sandys of the Civil Service, and which is merely an improvement on the common native bullock draw-well with leathern buckets, can be erected for Rs. 2,000, and raises a ton of water per minute ; 720 tons or 160,000 gallons lifted daily, would in the course of three days fill a tank such as that in Wellington Square.

The Municipal Commissioners have stated in para. 30 of their Report to the Lieutenant Governor of Bengal, dated 1st January current, that they have it in contemplation to erect another Engine, similar to the Chandpal Ghaut one, in the northern part of the city, for the supply of that portion of it.

Those tanks which are on the Maidan are supplied with their water from the drainage of the Rain fall over that large surface. But as great numbers of cattle are permitted to graze at all times over it, there can be no doubt that the water of those tanks would be sweeter and would require less purification if they, like others were supplied with river water from the aqueducts.

Residents in the Fort draw their best water from the Havildar's tank, immediately south of the Fort on the Maidan.

Quantity of Well Water.

The quantity of water drawn from wells in Calcutta is very large. They are so easily dug, and are capable of affording water sufficiently clean for ordinary bathing and washing purposes for so long a period, that their construction is universal and there is scarcely a compound without at least one well in it, from which the servants and all the lower classes draw their supply for their daily bath, and for the washing of their clothes and their cooking vessels after eating.

Towards the close of the hot season however the greater part of these dry up, being of but small depth, or else the water becomes so scant and foul or brackish, as to be no longer fit for use.

The natives are then obliged to resort to the tanks, or else to purchase water from bheesties and water carriers.

The price of water thus purchased is usually 1 pice for a mussuck. A mussuck contains on an average $1\frac{1}{2}$ cubic feet of water or about $9\frac{1}{2}$ gallons; and 16 pice, or sixpence English money, would thus purchase 152 gallons.

In towns in England where the supply is scant, water is sold at sixpence the cart load of 300 gallons, which is about $\frac{1}{2}$ the price of the foregoing, or $\frac{1}{2}$ a pice per mussuck.

Quantity of Rain Water.

The annual amount of rainfall at Bombay is 76 inches on an average of 34 years; 15 miles from Bombay however, in the hills, it is as much as 100 inches per annum.

That of Madras is 44·57 inches on an average of 21 years from 1822 to 1843.

That of Calcutta 67 inches for the last 5 years.

This quantity of rain water is sufficient not only to fill the tanks, but to give a surplus which passes off by the city drains. The slope of the drains however is so small, and the quantity of rain which falls in a short time so great, that the streets are sometimes flooded, and it takes several hours for the waters to flow off.

Water supply as it might be.

Such is the state of the present supply of water in its different forms to Calcutta. It remains to be considered how this supply could be improved.

There is not room for much selection in the matter. Of the three sources from which a water supply can be derived as described in Mr. Conybeare's Report, *viz.*, 1st. From the water of rivers or running streams. 2nd. From deep springs or well

water 3rd. From surface collection or rain water; Calcutta does not possess the second source at all, there being no deep springs in it.

As regards the third, much, perhaps the greater part of the present supply of Calcutta is from surface collection or tanks. In Madras and Bombay it is the same, but Calcutta possesses besides this the advantage of a noble river whose supply is inexhaustible. The city of Bombay derives a portion of its supply from springs as well as from tanks, and under the new proposed system will draw the purest of waters, rain water, from a capacious and magnificent mountain reservoir holding nine thousand million gallons.

It will be as well to glance briefly at the schemes which have been proposed for the supply of water to these cities and then to consider:—1st. The requirements of Calcutta and the benefits derivable from an improved water supply.

2nd. The quantity required or extent of supply; and 3rd. Its probable cost.

Bombay Water supply.

The scheme for the supply of Bombay has been carefully drawn out and considered in its details by Mr. Conybeare and by Captain Crawford and Lieutenant Delisle of the Bombay Engineers. Its chief feature is the throwing of a dam across a gorge in the valleys of the mountains of the Island of Salsette, whereby a large amount of natural surface drainage which has hitherto been passed off down the Vehar valley by the Goper river, will be ponded up in a reservoir averaging 42 feet deep, and at the dam 85, and containing as before stated above nine thousand million gallons.

The base of the dam will be 92 feet above the general level of the city of Bombay. The water from the reservoir will be drawn off through the walls of a lofty masonry tower built of porous filtering stone, and will thence pass direct into the main iron pipe which is to lead it to Bombay.

Further purification by filter is not considered requisite, and the head of water obtained by omitting this is greater; being as much as 130 to 150 feet.

Leaving the filtering Tower the water will pass by an iron pipe 3′ 5″ in diameter to Bombay, a distance of 14½ miles, and will there be laid by means of iron pipes aggregating 54 miles in length, through all the streets of the city, supplying Reservoirs and Conduits in them for public use, and jets for the extinction of fires, for fountains, &c.

If the population be taken at 500,000 and the daily supply per head at 20 gallons, this would make the supply ten million gallons, or the total annual supply say four thousand million gallons. This leaves a large surplus in the Reservoir, of at least as much again, for evaporation, wastage, &c. The service is constant, at high pressure and by gravitation.

The cost Mr. Conybeare estimates would be 5 rupees per head or 25 lacs of rupees. The cost of supplying 25 gallons of water would then be 1 pice, or one-

third of its present cost in Calcutta and much less than that of course in Bombay where actual drought occurs in the dry weather.

The date of Mr. Conybeare's last or second scheme is 13th March 1855, and of Major Crawford's Report on it, 20th April of the same year.

Madras Water supply.

The scheme for the water supply of Madras has been prepared and worked out by Lieutenant O'Connell of the Madras Engineers. The water is to be derived from capacious tanks to be formed by enlarging existing ones at some distance from Madras, by means of embankments. One of these, 10 miles to the North-West, is to supply the North part of Madras or the city proper, is called the Parel or Red Hill Tank. The other 13 miles to the South-West, is to supply that part of Madras which lies to the South of the River Cooum, a River flowing from the Westward into the Sea at Fort St. George.

The supply for the latter is drawn from a series of embanked tanks at and beyond St. Thomas' Mount, the chief of which is the Pommel tank. From these it flows in an open navigable channel about 13 miles in length to Madras, where the requisite Reservoirs, Filtering Beds, and pumping machinery are to be constructed to lay it on to the city in a constant supply, at high pressure, with a head affording a jet of from 30 feet in the day, to 70 and 80 feet under the most favorable circumstances at night; and to the amount of 30 gallons per head of the population.

The Pommel tank is beyond St. Thomas' Mount. Immediately below it and at the Mount itself, is another tank called the lower tank. In this the surface of the stored water will stand at 33 feet above the mean sea level.

The Pommel tank when full, will contain a body of water, (the collected drainage of the valley of the Adhyar of 178 square miles extent,) amounting to 127 million cubic yards. Its surface area will be 15½ square miles, and its greatest depth 20 feet.

The Red Hill Tank when full, will have a surface of about 5½ square miles and a mean depth of about 13½ feet. It receives the drainage of about 20 square miles of the valleys of the Cortelliar and Cooum Rivers, and will hold 43 million cubic yards of water.

The supply for the North of the city is brought in a similar manner, and laid on under similar circumstances from the Red Hill Tanks distant about 10 miles to the North-West of Fort St. George, being pumped up a stand pipe to a height of 100 feet when it reaches the city.

The tanks and navigable channels which collect and conduct the water, are intended also to conduce to the improvement by irrigation, of that part of the country through which they pass, and hence the whole expense of the works will not fall entirely on the city water supply and drainage improvement funds.

Lieutenant O'Connell states the expense of the water works for the South por-

tion of Madras as Rs. 18,59,570, and that for the Northern portion as Rs. 19,32,126, total Rs. 37,91,696.

The daily supply of water for the population of both portions of Madras, which together comprise 27 square miles, taken at 700,000 persons, at 30 gallons per head, is 21,000,000 gallons and the cost per head is therefore Rs. 5-7 annas.

The date of Lieutenant O'Connell's report is 23rd March 1853.

Calcutta Water supply.

The schemes which have been devised for supplying Calcutta with water are two. One prepared by Mr. Simms, Consulting Engineer to Government, in February 1847, and another a modification of Mr. Simms' prepared by Mr. Hawkesly, Civil Engineer, and Captain C. B. Young, of the Engineers, in February 1852.

By Mr. Simms' project, the water for the city was to be pumped up from the river Hooghly at Fultah 13½ miles above Calcutta by an engine of 200 horse power. It was then to pass into two Circular settling reservoirs, each of 1,000 feet diameter and 12 feet deep, from which it was to pass down an open aqueduct to Calcutta.

On the Northern limit of the city it was to be purified by filtering reservoirs, and being then received into supply tanks, was to be pumped by engines of 300 horse power through all the streets of the city aggregating 142 miles in length, and to be forced into cisterns on the tops of the houses from which the supply for daily uses was to be drawn.

Mr. Simms in his calculations for supply, assumed the population at 250,000. The quantity of water required per head 30 gallons, and total daily supply therefore 7,500,000 gallons. The amount of his estimate was 67 lacks of rupees and the cost per head of the population therefore nearly Rs. 30.

The scheme proposed by Mr. Hawkesly and Captain Young, was a modification of the foregoing, based upon the considerations of its great expense which rendered it impracticable, and of the absence of the necessity for imposing upon a people little able or willing to pay for it, a system so extensive and in some respects objectionable to them in its details.

By this scheme the water was proposed to be obtained in the same way at Fultah by engines of 60 horse power; brought thence to the city in a covered or circular brick aqueduct 4 feet diameter; there filtered, and then pumped by engines of 200 horse power over a stand pipe 80 feet high for distribution on constant supply at high pressure to the city.

It was proposed to extend the full supply to every street in the European portion of the city only, which numbers according to the census of 1850, 100,000 European, Eurasian, and native inhabitants.

As this quarter is however in the south, and the water works would be on the north of the city, it would be necessary for the mains to pass through the native part of the city before reaching the European quarter. It was therefore intended to

carry three large mains aggregating 10 miles in length, through three of the principal North and South thoroughfares of the city, *viz.*, Chitpore Road, Cornwallis Street, and Circular Road, and after giving the general population the benefit of numerous public fountains derived from these, to lay the water through 50 miles of pipes in the streets of the European quarter. The total of the pipeage would thus be 60 miles. Should the water be found to be acceptable and come into general use, it was proposed to extend the system subsequently. In the mean time the water drawn from the fountains and used in their own houses, and the surplus and wastage from the fountains themselves, would materially aid the defective drainage.

The daily supply by this scheme, calculated at 20 gallons per head, would be 2,000,000 gallons; or adding one million for Government and public purposes 3,000,000 gallons. The calculated cost was 16 lacs of rupees, or for the European population supplied (and not including any thing for the native portion of the city, which however would also have benefitted to some extent) Rs. 16 per head.

Should it be determined now or at any future time to give Calcutta the benefit of a water supply, it will remain for those to consider, to whom the project in all its details is entrusted, how this may best be effected. Whether by a system complete in itself and supplying filtered water to all parts of the city at high pressure, or whether, considering the habits and prejudices of the people, and the systems adopted in Continental Europe, where more is drawn from public fountains than in English towns, it will be sufficient to extend the system which is now in operation, and supply water to tanks and fountains in the different parts of the city by several engines of smaller power situated at different and favorable points along the bank of the river, or by one large engine.

Requirements of Water supply.

It will be sufficient in this place to point out a few of the requirements which any system, whatever it may be, should endeavour to supply, and the benefits which would follow from so great a boon to all classes.

In the first place it is desirable to point out how intimately, if not inseparably, a good supply of water is connected with efficient drainage, particularly in cities situated as are Calcutta, Madras, and Bombay. The following extracts will tend to do this.

In the minutes of consultation, dated 24th June 1854, the Governor in Council of Madras, after stating how clearly the benefits derived by the population of large towns from sanitary measures ably carried out, have been proved of late years, says—"These sanitary measures depend chiefly on *a plentiful supply of water* and upon a well organized system of sewerage."

Again in the minutes of consultation, dated 2nd May 1855, he writes para. 7—"The first and most requisite, and that indeed on which all the rest must depend, is the *supply of water.*"

Colonel Faber, the Chief Engineer, writes para. 2—"The first object to which, after the study of the papers, Lieutenant O'Connell's investigation and attention should be directed, is the means by which the storage of an adequate body of water for the use of the inhabitants of Madras may be provided for."

And again para. 17—"In the foregoing instructions provision for the cleansing of the drains has not been prominently mentioned, because it is believed that the mere addition of the *supply of water* to the inhabitants, will inevitably afford great help to more effective drainage."

Lieutenant O'Connell writes—"For the effectual sewerage of a town, it is absolutely necessary that some means of periodically removing the contents of the sewers should be provided. If they be underground sewers, it is necessary that a scour should be obtained by passing bodies of water through them, either continuously or periodically."

And again—"The diminution in this (the water supply) will be felt not only in the quantity of water supplied for drinking purposes, but also in the state of the sewers: for flushing which, *water* is more required than for any other purpose."

Mr. Clark writes in his Calcutta drainage report, para. 27 as follows:—"Were Calcutta well and properly supplied with water, without doubt these sewers, if well constructed, would be kept perfectly clean and free from deposit."

"It" (the want of water) "here presents itself in another form, and to those who can understand all the benefits which a good water supply affords, with almost equal urgency as at Bombay."

"It is well known that the filthy matters produced in the thickly populated towns of England, and such as those of the cook-rooms and bath-rooms of Calcutta, are best and most effectually removed in suspension by running water; if this be so in a temperate climate, how much more desirable must it be in a tropical one, where decomposition of animal and vegetable substances is so much more rapid. Moreover, it is well known that when the town has a proper water supply, and a well devised system of sewers, no other water power is necessary to secure the rapid removal of those matters, as soon as produced."

And the Municipal Commissioners remarking on Mr. Clark's report observe—"In the Northern Division of the town additional means of *water supply* are proposed, and will be *absolutely essential* for any efficient scheme of drainage."

The Metropolitan sanitary Commissioners in their first report of November 1847 say—"It was also proved and urged that for the perfect attainment of these objects" (sewer self-cleansing) "the command of artificial supplies of water was requisite."

In the printed evidence of Mr. Phillips it is stated—"Indeed it is *utterly hopeless* to expect that house drains and sewers can keep themselves or be kept clean and in perfect condition, without having at the same time control over a supply of water."

Mr. Dempsey, Civil Engineer, in a late work (1854) which comprises most of the information obtained of late years in drainage matters, commences the subject thus—"According with our definitions we propose to treat of the *supply of water* to towns and buildings as a branch of the general subject of drainage, since the purposes of the art cannot be effected without an adequate and regulated *supply of water*, &c."

Again, "From the principal here laid down, it will be understood, that in the two-fold purposes of the drainage of towns, *viz.*, the *supply of water* and the discharge and disposal of the refuse matters, the relative levels of the town should be considered."

In explaining how the water which is supplied should be made use of, he shows that artificial flushing from certain points is inferior to a diffused and general supply to all the houses, and through all the different parts of a town. He says, "As a general principle to be very reluctantly departed from, the surface water and waste household waters should be admitted as the only dilutants of the solid sewage. Artificial scouring or flushing of the sewers, may be regarded as an expensive and troublesome correction of some of the evils occasioned by deficient declivity, &c."

In another part of his work (para. 373) he states that the cost of flushing as practised by the New Metropolitan Commissioners of Sewers has been reported as being about one-third that of cleansing by hand.

Mr. Simons writes in his reports on the sanitary condition of the Metropolis to the Commissioners of Sewers as follows:—

Para. 18. "One of the most important purposes of a water supply seems almost wholly abandoned, that, *viz.*, of having a large quantity daily devoted to cleanse and clear the house drains and sewers.

Para. 22. "About a month ago the Sanitary Committee of Nottingham, published what I may call a report of congratulation on their freedom from cholera, which had visited the town with great severity in 1832. They detail the measures by which Nottingham has been rendered a healthy town, and the first item in that enumeration stands thus; an *unlimited supply of wholesome filtered water* forced by day and night at high pressure through all the streets to the top of almost all the houses, at a cost for the dwellings of the poor of about five farthings per week."

Para. III. Again—"Those works of drainage which are established under your orders, depend for their efficiency on a proper *supply of water*, and in every case when you enforce the construction of house drains, you order that those drains shall be served efficiently with water."

Para. 115. House drainage pre-supposes water supply, water supply pre-supposes house drainage. The efficiency of either, implies their mutual adoption, just as the circulation of blood within an animal body implies uninterrupted continuity

of arteries and veins, each harmonizing with the uses of the other to ensure the efficiency of the whole.

Mr. Cresy, in his Encyclopedia of Civil Engineering writing on the drainage of towns, begins thus—"The next important requisite to a good supply of water is, the means to be relieved from it, when the uses to which it has been applied have destroyed its purity and loaded it with all the adulterations that it must incur in its final passage to its discharge."

The Metropolitan Commissioners of Sewers strongly recommended the substitution of a smaller system of sewers to be kept in action by regular supplies of water.

The extent of diminution recommended was for mains from 4′ 9″ × 3′ to 5′ 9″ × 2′ 5″ and for 2nd class sewers from 4′ × 2′ 5″ to 3′ 4″ × 2′. This is about $\frac{1}{3}$ in size, and the expense would have been reduced to $\frac{1}{2}$. They continue, "Supposing that all these points were gained in the laying down of our sewers, that there was sufficient inclination, a regular system of ramification, a faultless construction as to size, shape, and material, still there is one great requisite without which all others would be only partially successful, we mean an *abundant supply of water*, whereby these sewers might be kept always pretty full and occasionally thoroughly scoured from the remotest branch to the general embouchure."

"The drains," says Captain Vetch, who was on this commission and who has much experience in these matters, "but furnish the ways or vehicles for transportation. The water is the moving power or carrier, and it is the cheapest that can be procured. In fact the supply of water to a town, and the discharge of refuse, are two branches of the same subject, and unless the water is abundant enough to cleanse the drains, the last would be more offensive than useful. When artificial supplies of water cannot be obtained, the principle of flushing may be advantageously introduced."

"Such," he again says, "are the requisites for a regular system of drainage, from which it will be seen that underground sewers are preferable in most instances to open gutters, and that neither can be efficient without a *liberal and steady supply of water*."

It is unnecessary to quote further the opinions of those who are authorities on the subject, as all are agreed upon it. To cities situated upon low and level ground, a water supply is more than in other cases requisite as an accessory to drainage. Mr. Dempsey writes, "thus the flat districts on the margins of rivers and inland streams of adequate capacity are the most favorable sites for towns for the supply of water, but for drainage they are the least so. On the other hand, a town on a hill top is the most readily and cheaply drained; but its supply with water, whether from springs, rivers, or surface drainage all at lower levels, is a work of great and constant cost."

The same authority enumerates the purposes for which water is required in a town thus :—

1. Ordinary domestic uses including drinking, washing of persons' clothes, utensils, houses, yards, and watering gardens, &c.

2. Manufactures.

3. Supply of public buildings, baths, wash-houses, &c.

4. Extinction of fires.

5. Cleansing and watering of streets and thoroughfares.

6. Supply of fountains and public gardens and pleasure grounds.

7. Miscellaneous and occasional purposes not included in the foregoing.

To the whole of these (with the exception perhaps of drinking) water would be applied here as much as in England, and in some cases greatly more. In respect to manufactures and probably fires it would be less. But in watering gardens and roads, supplying baths and wash-houses, and for general use at the public fonts, whether in personal washing or in the cleansing of clothes, &c., &c., it would be far greater.

Indeed in a country where a bath is welcome at any time of the day or night for the greater part of the year; to both human beings and animals, where it would certainly not be too much if the public thoroughfares were watered three times a day, and where gardens during the productive season of the year are always dry enough to absorb with benefit as much water as can be afforded to them, it is impossible to say with any approach to probable accuracy, how much water would be used.

In watering it has been ascertained in London that a ton of water will lay the dust upon 600 square yards of macadamized road. If the roads in the Southern quarter of the town be taken, through which the aqueducts pass, that is, about 15 miles in length, and if their average breadth be assumed at 60 feet or 20 yards, it would require about 60 tons of water at each watering to a mile; or 2,700 tons for 15 miles watered three times a day. This is equal to 600,000 gallons, or, if the population of this quarter be taken as in Messrs. Hawkesly and Young's estimate at 100,000, it is an additional 6 gallons per head per diem of the population for this item alone.

If, however, the extent of roads watered, were doubled, as it easily might be, with advantage and very great benefit and comfort to the community; if for instance, the entire road encircling the Maidan with those which cross it in various directions, and if that bounding the city on the East (the Circular road) were planted like the Parisian Boulevards, and watered and rendered attractive to the European residents which they are not now, this quantity would be still further and greatly increased.

The main streets of the city, both in the European and native portions, would no less derive great benefit from such a supply. Where shops are situated, actual profit would result from the facility of watering, and it might be anticipated that much less opposition would also be made by the population to the opening out the new and wide thoroughfares, which have so long been considered necessary to the health of the city, but in effecting which such difficulty is now experienced.

It would be impossible to calculate the quantity that would be used for supplying plunge and shower baths in the houses and grounds of the more opulent, or in indulging in the luxury of fountains and aqueducts for compounds in a climate where water only is required to render every garden a conservatory for mearly eight months of the year. In all probability much of the expenditure and taste now devoted to the interiors of the Calcutta palaces, would then be diverted to the gardens and grounds, and with benefit to the health of the inhabitants.

As regards the poorer classes who now throng round the aqueducts in the hot months, it would not be easy to overrate the increased comfort and happines they would derive from the use of constantly running fountains of good water throughout the city, and of tanks in like manner distributed in all parts, and constantly kept filled, as the best ones only are now, with an abundance of wholesome drinking water.

The water thus supplied and carried to the houses of all classes, and *there* used, as well as poured out in the principal streets would be distributed in the most beneficial manner possible for assisting and improving the city drainage. That is, it would pass from the individual houses into the underground pipes, drains, and channels at their *very commencement*, and augmenting the body of liquid in each or diluting it *ab initio*, the united streams would form a volume which there can be no doubt would have a steady and equable flow, and be readily carried off from the city by the drains to be constructed.

If calculated with the foregoing considerations held in view, and with the knowledge that great part of the amount of water nominally supplied per head of the population of English towns is now found to go to waste, and not to come into use at all; that is, that a considerable surplus must be allowed for wastage, the amount of water which should be considered requisite for a city like Calcutta would be very great.

At present, during the hottest time of the year there is actually no flow from the outlets of the Calcutta main drains, their contents stagnate, thicken, and solidify in the channels themselves, and have eventually to be removed by hand. Such an evil can only be remedied by a water-supply, which of course would be most acceptable and most actively beneficial at the very time it was most required, namely, in the hot weather. Without it, a flow of sewage could scarcely be expected from the drains in the hot weather. Indeed, Mr. Hawkesly and other engineers in England, when referred to for an estimate of the amount of sewage passed off by the London drains, base their calculation entirely upon the amount of water thrown into the town by the water companies.

It is stated that as much as three-fifths of the water actually supplied in London runs to waste. "The enormous disproportion that the gross quantity of water supplied, usually bears to the actual net consumption, is attributed to leakage in the countless joints and fire plugs of the many miles of the distributing water-pipes, and

Mr. Conybeare's report, paras. 45 and 53.

to the enormous and continuous waste not only from the stand-pipes, but also from water-taps or stair-heads and within private dwellings; these latter sources of leakage are very numerous. For instance, there are 1,800 stand-pipes with $\frac{3}{4}$ inch taps belonging to the city of Glasgow water-works, and, besides this, a population of 165,000 supplied within their dwellings by probably not less than 80,000 taps." The actual personal consumption in London has been found after trials instituted by the Board of Health, to average only 5·7 gallons per head.

Although the quantity of water which would be used, if supplied by pumps, in Calcutta would without doubt be very great, it may be a question whether it would be necessary to force that water to any great height. Although water so forced would without doubt be useful in some of the public buildings, in the residences of the more opulent Europeans, and in cases of fire, yet it would not be nearly so useful or so necessary as in towns in England, where the greater part of the houses are two and three storied.

From Mr. Simms' report on Calcutta, we find that there are in Calcutta and Cooley Bazar as follows:—

Huts, ...	49,445
One storied pucka houses, ...	5,950
Two " " "	6,438
Three " " "	721
Four " " "	10
Five " " "	1

Or in general terms it may be said that there are 50.000 huts; 6,000 one-storied houses; the same number of two-storied, (or 12,000 one and two-storied houses together,) and 720 of three, four and five stories. Thus the larger "koties" or houses of the opulent classes, form 6 per cent. of the whole number of pucka houses in the city, and little more than 1 per cent. of the whole number of habitations including huts.

If we turn now to a record of the fires which have taken place in Calcutta during the last five years, as shown in the annexed paper prepared from the records in the office of the Chief Magistrate, we shall find that during that time there have been burned—

20 pucka	houses.
1,601 tiled	houses.
2,627 thatched	houses.
Total,..... 4,248.	

Statement of Fires in the Town of Calcutta, during the years 1851 to 1855.

Months.	1851.				1852.				1853.				1854.				1855.			
	Pucka Houses.	Tiled Houses.	Thatched Houses.	Total.	Pucka Houses.	Tiled Houses.	Thatched Houses.	Total.	Pucka Houses.	Tiled Houses	Thatched Houses.	Total.	Pucka Houses.	Tiled Houses.	Thatched Houses.	Total.	Pucka Houses.	Tiled Houses.	Thatched Houses	Total.
January, ...	...	...	7	7	...	10	63	73	...	10	3	13	..	9	17	26	...	5	55	60
February, ...	...	40	52	92	...	24	203	227	..	48	18	66	...	45	94	189	...	1	1	2
March, ...	3	...	24	27	...	69	61	130	6	170	872	1048	...	19	37	56	...	31	33	64
April, ...	...	133	12	125	...	4	4	8	...	199	323	522	1	17	68	86	...	26	54	80
May, ...	...	88	121	409	...	...	...	...	...	55	158	213	...	1	...	1	...	4	6	10
June, ...	...	...	1	1	...	...	...	...	...	19	9	28	...	...	...	...	...	..	1	1
July, ...	..	1	11	12	...	...	...	...	...	..	1	1	...	...	...	...	...	...	...	...
August, ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1
September, ..	..	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	1	..	1
October, ...	1	...	2	3	...	3	2	5	...	...	2	2	...	...	1	1	...	..	3	3
November, ...	...	130	24	154	...	60	4	64	...	34	31	65	...	...	23	23	7	190	74	271
December, ..	...	6	12	18	...	108	12	120	..	1	66	67	...	19	8	27	1	21	54	76
	4	398	266	668	...	278	349	627	6	536	1483	2025	1	110	248	359	9	279	281	569

That is; the proportion of pucka houses which took fire to tiled houses is 1·24 or 1¼ per cent. To thatched houses ·76 per cent., or about 8 of one to 1,000 of the other. And to both together ·47 per cent., or about 5 of one to 1,000 of the other two. Out of these 5, it may be not unreasonable to suppose that they are

Memo. of the number of fires that occurred in the town of Calcutta, during the above years.

1851,	30
1852,	38
1853,	78
1854,	29
1855,	40
Total,	213
Average,	43

(Signed) S. WAUCHOPE,

Offg. Commissioner of Police.

all small, either one or two-storied houses, as such a thing as a fire in a three-storied kotee in Calcutta, is scarcely within "the memory of the oldest inhabitant."

From the same return it appears that the number of fires annually, is on an average of the last five years, 43. Mr. Conybeare states (para. 291,) that in Bombay it is less than 50, (41) and in London that it is 800.

With a due consideration for these points, and to the cheapness of labour, which would enable water easily and inexpensively to be carried to any height, if once laid on in the compound, and also to the continental systems of supply, where more attention is devoted than in English cities to the supply of public fountains in the streets, it may perhaps be found to be preferable to give an abundant supply laid on at high pressure to an altitude of 30 feet only, to incurring the expense of forcing water to the tops of the highest houses. This would be a matter, however, for further and fuller consideration.

The few large hospitals or public buildings which require water urgently at high pressure in every part, might be supplied as the Medical College Hospital now is, by their own small engines.

The watering of roads with jets of water from the road sides has not been found so effectual in England as the water cart, which distributes the water more equally, and less disturbed by the wind.

We will conclude with a rough estimate of probable cost of a water supply such as has been spoken of.

The supply per head of the population at Madras, we have seen is taken at 30 gallons by Lieutenant O'Connell. Mr. Conybeare has made his calculation at 20 gallons per head, and at this amount we also will estimate it in the present calculation. That is for a population of 450,000 9,000,000 gallons, daily or 63,000,000 gallons weekly. The Chandpal engine now supplies about 90,000 tons weekly. If this be deducted it will leave 1,91,250 tons required, say 200,000 tons weekly.

The cost per head at both Madras and Bombay is about Rs. 5. But in both cases it must be remembered there is a long aqueduct 13 or 14 miles long. In one case an open canal, in the other an iron pipe through which the water has to be conveyed from its origin to the city. Mr. Conybeare states, (para. 137 of his 2nd report) that the average rate per head of the London water works has been £2-5-9, but that it has been said, that had London now to be supplied anew, and by one company instead of nine, £1 a head would be found sufficient or Rs. 10. If the water for Calcutta were pumped direct from the river (as it is now), filtered, and laid on after being pumped over a stand-pipe, 60 or 80 feet high, for bathing, road watering, and all common uses, and the tanks supplied only when necessary with drinking water, the expense would be much diminished, probably to one-half the Bombay expense or only Rs. 2-8 per head.

Rs. 2-8 per head would amount for a population of 450,000 to Rs. 11,25,000.

The cost of pumping on a large scale has been carefully observed and recorded

by Mr. Wicksteed. This cost varies much with the kind of engine used, but if the average be taken, it is stated that to raise 160,000,000 gallons 100 feet high would cost £230,

Or	320,000,000 gallons,	50 ft. would cost	£230
That is	1,428,570 tons,	50 ft., ditto	£230
Or	200,000 tons,	50 ft. ditto	£32-4 or Rs. 322

To compare this with the cost of pumping water at present by the Chandpal engine. This is as before stated Rs. 6,000 annually, and the quantity raised say, 90,000 tons weekly to a height averaging 25 feet.

That is 90,000 tons raised 25 ft. cost $£\frac{600}{35} = £17\text{-}3$ weekly.

Or 90,000 tons raised 50 ft. would cost £34-6

Or 200,000 tons raised 50 ft. would cost £76-4 = Rs. 762

The price of coal in this calculation of Mr. Wicksteed's, is taken at 12*s.* a ton. The price of Burdwan coal may be taken at 1 anna a maund at the pit's mouth and 2 *a.* 8 *p.* for carriage. With all other expenses included, say 6 annas a maund as the cheapest. That is equal to 21*s.* a ton, or 75 per cent. more than the English price, and if the English cost of pumping be proportionally increased, it would be rupees 322 + 241 = Rs. 563, which would be considerably less than the cost now incurred of pumping by the Chandpal engine. Other English engines pump cheaper than this, but the above is the average of several given by Mr. Wicksteed.

"The expense of raising 1,000 gallons to an average height of 80 feet is found by the Trent Company to be (excluding interest on capital,) less than $1\frac{1}{2}d.$, and the cost according to Mr. Wicksteed's Table of results, of raising 1,000 gallons to a height of 100 feet with a single pumping engine on the expansive principle excluding interest on capital and repairs of machinery is less than $\frac{1}{6}d.$ or 15*d.** Although the first cost of engines and pump machinery of this class is very heavy, it will be a liberal allowance to balance this with the remaining ·85*d.*, and we shall then have an average cost of 1*d.* for raising 1,000 gallons to an elevation of 100 feet." According to this, to raise 63 million gallons weekly to a height of 50 feet would cost Rs. 68,250 yearly.

The prime cost of the machinery to raise the water, of laying down the pipes to distribute it, and the reservoirs and filters to receive and purify it, might be also calculated as follows:—

3 Engines 120 H. P., at £200 per horse power,	= 2,40,000
90 miles pipes at £800 per mile,	= 7,20,000
Filtering 9 million gallons daily at 1*d.* per 6,000 gallons,	= 22,750
Reservoirs, Fountains, &c.,	= 67,250
Total, ... Rs.	10,50,000

* By the foregoing calculation, ·34*d.*

DRAINAGE COMMITTEE.

APPENDIX N°. V.

EVIDENCES.

APPENDIX.

I.

DRAINAGE COMMITTEE.

QUESTIONS BY COMMITTEE.

1. WHAT, in your opinion, is the direction which should be given to the general drainage of Calcutta?

2. Have you any doubt on this point, or is there any other available fall or direction which might be adopted?

REPLIES BY MR. W. CLARK, C. E.

1. TOWARDS the lowest permanent level in the vicinity of the Town, which is, or may be, connected with some natural stream, and which is unobstructed by the rise of tidal water, or by any other impediment to the constant discharge of the sewage.

The Salt Water Lake and streams connected therewith appear best to satisfy the above conditions.

2. I believe the above to be the only available out-fall. Apart from the favorable inclination of the surface of Calcutta, from the River Hooghly towards the Lake, the variation of the surface level in the latter is less affected by the Tide and change of season than the River.

The average high water of Springs and Neaps, in the River Hooghly, varies from 17·41 to 12·83, while in the Lake the surface is stated to vary only between 8 feet 10 inches and 9 feet 8 inches above datum. In the Canal at Dhappa, I believe it will be found that the surface never rises above 11 feet 2 inches above datum.

The Lake therefore offers a constant outfall permanently lower than the river; moreover, the out-fall of a system of covered sewers into the River, from the considerable rise and fall of the Tide, could only be intermittent.

3. To what extent, or for what distance, must artificial (that is engineering) means be adopted, before those afforded by nature for relieving the drainage could be taken advantage of?

3. I have recommended that an Engine be erected for the discharge of the drainage during the dry season; this would be almost exclusively house drainage, and represented in quantity by the amount of water supply: it would be lifted by the Engine and discharged through a separate covered sewer to the Salt Water Lake. During times of heavy storm, when the quantity is so enormously increased as to render pumping almost impossible, it would flow off through the Canal: at such times the drainage being almost entirely rain water, it would be inoffensive, and its discharge by this channel would not be productive of nuisance. It is during the dry season that the drainage is offensive, and the plan of lifting and discharging it by a covered channel is recommended for the certainty and completeness with which the sewage would be removed out of the limits of the Town, without any nuisance whatever, even near the proposed Engine, by an arrangement which may be adopted for the purpose. (*Vide* No. 20.)

4. Describe the advantages afforded by the nature of the Salt Water Lake, or which, in your opinion it offers towards assisting a plan of general drainage?

4. The advantages derivable from the *Lake*, apart from the streams running through it, would probably be only of a temporary nature, as the Lake is said to be silting up: if the sewage assisted in this operation, it would be a desirable result. The central channel through the Lake, however, would always carry off the drainage; the advantages afforded by this are comprised in its comparatively small variation of surface level, and its *constant* depression below that of the surface of Calcutta.

5. If no Circular Canal had existed, what plan would you then have suggested for the drainage of Calcutta?

What would be its cost, and difference between its amount, and that of your scheme?

5. If no Circular Canal had existed, I should certainly have suggested that an open drain be cut to the Lake, to supply the facilities which it gives for the removal of storm-water; it may be found desirable to do this hereafter, and thereby relieve the Canal

almost entirely of any portion of the sewage.

6. What are the limits of the land jurisdiction of the Municipal Commissioners? Describe them on a Map.

6. The land jurisdiction of the Commissioners, for the purposes of drainage and water supply, are, by Section XII. Act XII. of 1852, and Section CXVIII.* of the amended Conservancy Bill, now before the Legislative Council, unlimited. For other purposes, they are comprised within the Mahratta Ditch running along the Circular Road, Chowringhee Road, and the River from the North of Chandpaul Ghaut to the Canal at Chitpore.

7. Do you consider it absolutely essential, that the main arteries of drainage should be assisted, in carrying off the Town sewage, by a flush from the River?

7. For the present *yes*, but when Calcutta has a proper water supply, I think no special arrangement for flushing would be necessary. (*Vide* para. 13 of Report to the Commissioners.)

8. Would this, in your opinion, be sufficient?

8. Yes.

9. At what do you estimate the fall from the River to the Salt Water Lake in the dry months, taking Spring Tides in the River and highest water level in the Lake?

9. Average level of Spring Tides in the River by Simms' levels ... 17·41
Highest level in the *Lake*, by Schalch's ... 9·66

Fall ... 7·75

10. The same, taking Neap Tides?

10. Average level of Neap Tides in the River, by Simms' levels, ... 12·83
Lowest level of Lake, by Schalch's 8·8

Fall .. 4·03

11. The same. Neap and Spring Tides Rainy Season?

11. Average high water Spring Tides in River, by Simms' levels 17·41
High water Spring Tides in Canal at Dhappa, February 8th 1856 ... 11·11

Fall ... 6·30

* Section CXV Act XIV. of 1856.

Average High Water Neap Tides in River by Simms' levels ..	12·84
High Water in the *Canal* at Dhappa, January 29th 1856...	9·91
Fall ...	2·93

12. Would this amount of flush be sufficient to carry sewage as far as the tidal influences in the deep channel connected with, or running through, the Salt Water Lake; if so, at what point would it enter the passage?

12. I have no doubt, at Spring Tides, this flush would carry off any deposit from the four main receiving sewers which might collect during Neap Tides. If a deep cut be brought from the deep channel, about 1 mile to the East of Dhappa to Entally, it would be 3½ miles long. This, added to the length of the main sewer, from Nimtollah or Tolly's Nullah to Entally, 3½ miles, nearly gives a total length of about 7 miles.

I am not prepared to say that the entire amount of the silt would be conveyed to that distance by the flush from the River.

13. Or would a lift, by means of an Engine, be absolutely necessary?

13. If this deep cut be carried up to Calcutta, the Engine might not be immediately necessary, until it is found that the silt is not entirely removed to the full distance required, when a similar arrangement to that proposed by me at Entally might be constructed to intercept it. This deep cutting would affect private property to a considerable extent, which probably it would be well to avoid.

14. If such a lift were established, would it not, by building a dam across the main outlet, diminish the influence of a river flush to some extent?

14. Gates would be constructed at the Eastern end of the Silt Pit, to open outward towards the Canal: these would, of course, be open, when the operation of flushing was going on. No permanent dam would be constructed across the Canal. The Silt Pit would be entirely below the level of the inverts of the sewers.

15. Does not your system (supposing a lifting Engine at Entally to form part of it) involve the clearing out of Silt Pit,

15. Yes, I am apprehensive, that it will scarcely be possible to *flush* all the silt into the deep channel through the Lake, and if so, boating would be the cheapest

the soil of which would have to be carted or boated away?

plan to be adopted for carrying it away. In the event, however, of the proposed deep cut being adopted in lieu of the Engine, it would not be desirable to construct the Pits till found absolutely necessary.

16. The size of your Silt Pits would be, as the Committee understand, about 20 feet broad by about 8 feet deep each. Their length you have not stated.

16. *Vide* para. 38, Report to the Commissioners, in the Estimate it is given—

"Silt Receiver forming a double canal, each 25 feet wide and 6 feet deep, 300 feet long, at Rupees 100 per foot run."

17. What size is the present Silt Pit at Entally? What is the amount of silt excavated annually for each of the last five years in cubical measurement separately for the Entally Pit and the cutcha drains of this City, and expenditure thereupon? What becomes of the silt so removed and carted away, where deposited; is it used as manure and is any remuneration derived therefrom?

17. The Entally Silt Pit is 300 feet long and about 40 feet wide. The silt is deposited in any waste places which can be procured; hollow and uneven places are filled up and levelled with it; tanks filled up, &c.; but no remuneration is derived therefrom by the Conservancy.

18. If this Silt Pit, which becomes full, and is emptied out yearly, contains the deposit from the drainage of about one-fourth part of Calcutta only, and if a vast quantity more is excavated out of the kutcha drains of the City during the dry months of the year, and carted away, then the deposit in your proposed Silt Pits, into which all the drainage of Calcutta would pass, might be anticipated to be very great—might it not?

18. The total amount of silt excavated from the present drains, which is enormous, I think gives no correct indication of what would be found in a better system. This silt consists principally of road detritus, which is washed into the drains during heavy storms. During the annual excavations of the kutcha drains, which now chiefly predominate, whatever part is found to be soft, or what is termed "sludge," is removed, this is to a great extent the natural soil, sodden with the liquid contents of the drain, and is therefore removed as silt. Kutcha drains, it is well known, become wider and deeper by this process.

These two are the chief sources of what is termed silt. That from house drainage is very insignificant in amount, all or nearly so of the dust and rubbish, which would, in a sewer, form silt is removed by the Conservancy carts. The chief source of silt, in a proper system of sewers, would be the road detritus: this applies only to the times of

heavy storms, and therefore almost exclusively to the four months of the Rainy Season. The quantity would, however, be diminished by the less amount of scour incidental to the channels at the surface being all made pucka, instead of as now mostly kutcha.

The greater portion would be intercepted by the Cess Pits proposed to be constructed at intervals of 150 feet apart on both sides of the streets; the heavier particles would fall to the bottom of these Pits, which would require constant attention during the Rainy Season, for the purpose of keeping them cleared of this silt; that which remained being lighter would be more easily removed by running water in the sewer, at such times abundant, and would I believe be completely removed to the larger Silt Pit at Entally, which is intended as a convenient arrangement for facilitating its removal without affecting the Canal.

I may also remark, that the present branch Balliaghatta Canal silts up chiefly from the fact of its receiving the muddy water from the river at every tide, this water coming to a state of rest, deposits the mud which accumulates there in so large a quantity. I have not made any accurate calculation of what this silt might be expected to amount to, but I consider, it would be much less than at present; and so far as the Silt Pit at Entally is concerned, it would be in a more favorable position for complete removal.

19. The process of cleaning them out alternately might be expected to be going on frequently, and how often?

19. The Entally Silt Pit only would require to be emptied at intervals throughout the year. The constant, or nearly so, working of the Engine, would keep the water in motion, and to some extent prevent deposit of the lighter particles. The most deleterious and offensive portions of the filth are *dissolved* in water, the particles

which are in *suspension* are principally sand and not in themselves offensive.

20. If the cleaning out of the present Entally Pit, once a year, is such a nuisance, and the cause of so much illness and discomfort, as to prevent the near residence of any but the poor, would not the cleansing under your system be likely to prove a greater nuisance?

20. A large accumulation of filth is a constant source of nuisance to the neighborhood, and its removal at long intervals is likely to be productive of an increased amount of discomfort, and probably also of malaria and sickness. The frequent removal of such filth, though productive to a certain extent of annoyance, is greatly less injurious than in the other case. This is, as I conceive, the difference between the Entally Pit as it is now, and what it would be.

The Entally Silt Pit is cleaned once per annum, and at such times creates I believe an intolerable nuisance; at all other periods of the year, it is a stagnant hole filled with decomposing filth, which is undoubtedly highly injurious.

If nuisance from the Silt Pit as I propose it be apprehended, it is arranged so as to admit of its being entirely covered over, as alluded to in para. 33 of my Report. This is not provided for in the Estimate, but if it were done, the Pit would of course never be exposed to the sun, and it would then, by a simple arrangement for ventilation in connexion with the Engine furnace and chimney, admit of the silt being emptied into boats, however offensive that silt might be, without producing the slightest nuisance in the locality.

21. A constant natural out-fall, with the sewage in a fully liquid state, that is carried in suspension by plenty of water, might obviate this. Is it obtainable, do you think?

21. If a constant natural out-fall could be obtained, and the sewage be properly diluted, it would flow off completely, if *the sewers have sufficient fall*, and the other arrangements proposed would not be necessary. I do not think however these conditions are so perfectly attainable as to render artificial assistance entirely unnecessary. So far as the internal arrangements

of the system are concerned, what I have endeavoured to do is to make the most of the small fall which really exists.

I do not think more fall could be given to the system generally than as I have arranged it; if more of the fall actually existing be given to one part of the system, it must be at the expense of another portion.

With reference to the out-fall, the assistance of a small Engine would not be a heavy expense for such a purpose, and would ensure the constant and complete discharge of the sewage of the entire City during eight months of the year, and during all other times, excepting on the occurrence of violent storms. (The expense of working and repairing the Chandpaul Ghaut Engine during 1855, *exclusive of Superintendence*, was Rupees 4,354.)

22. If water, therefore, could be laid on to the centres of all the blocks of the City, so as to dilute and sweep away before it the filth and sewage from its very sources, would it not be beneficial and desirable?

22. Decidedly, and no system of sewerage can be expected to work perfectly, and without constant attention, until a proper water supply be laid down; but it is first necessary that the sewers should be provided. As this question is put, it *presumes* the existence of the sewers, and correctly, for they are indispensable to such an arrangement.

23. Is your water supply intended to provide this throughout the City?

23. The water supply proposed by me is intended to convey water to the summits of all the sewers. I have shown on the Plan, and is necessary in the Northern Division of the Town, where there are no aqueducts at present, for the purpose of cleansing the sewers. In the Southern Division, and where aqueducts already exist, these would be made available for this purpose. As the various blocks are filled in with minor drains, so must pipes be laid down from the minor mains or aqueducts. I presume that, at some time, a proper and efficient water supply must inevitably be provided for this City, and then no special

works of any kind for flushing will be required. In the meantime, it is not necessary that all the sewers should be *simultaneously* flushed, nor that they should be flushed *every day;* it is intended, by the assistance of flushing doors, &c., within the sewers, to give facilities for concentrating the flow of water upon any one particular sewer as required; I think the works proposed would, if properly managed, keep the public sewers clean.

24. Supposing the whole sewage of Calcutta then to arrive with certainty, and in a properly liquid state, at such main sewers, do you consider that its subsequent disposal and complete removal beyond the limits of possible nuisance or noxious influence would be ensured by the foregoing means of a River flush, main sewers, and Salt Water Lake out-fall, or would any other means be required to ensure its ultimate satisfactory disposal?

24. I think no other means would be required than those I have intimated in the Report.

25. What would be the expense of thus much of a system of drainage?

25. The Estimate for those works I propose first to construct is given in para. 38 of my Report to the Commissioners, and amounts to Rupees 15,56,411.

26. What do you consider the best direction for the main sewer or sewers to take through Calcutta?

26. East and West.

27. Would not the main Colootollah sewer be above the ground level when passing through the low part of the City at College Street, the level of which is only 20·28 above datum. If so, to what extent?

27. No, the level of the sewer invert there is above datum ... 10·00 feet

Height of sewers and thickness of works ..	8·25
Deduct this Total ...	18·25
from the surface level, *viz* ...	20·70
Leaves ...	2·45 feet.

There would therefore be 2 feet 6 inches of cover over this sewer at that part, which, would be sufficient.

28. Would not this, *viz.* running the main sewers through the lowest parts of Calcutta, in case of the sluices being mismanaged, or the sewer leaking or bursting, be liable to cause the inundation in the rains especially, of all that part, *viz.* the lowest, about Machooa Bazar, of the City?

28. There is no danger to be apprehended from this cause. It is usual, in such positions to have more than one sluice; in particular cases three are fixed; but two, with occasional examination by responsible Officers, is abundantly sufficient. The European Overseers of Divisions would be quite capable of managing them.

The whole of that District of London lying on the South of the Thames is drained by sewers, the outlets of which are more or less submerged *every tide*, and it is precisely the same with the entire Town of Hull.

29. Would not the sewer in other parts, *viz.* near the River, be very deep below ground—would it not there require excavation, which would be dangerously deep in the narrow streets of the City?

29. The average depth of no one sewer exceeds 12 feet—at this depth, the largest sewers, 8 feet diameter, may be laid in a street 20 feet wide, with safety to pucka buildings if properly managed.

30. The River flush would be admitted at high water and allowed to act as long as the height of the river admitted of it—how long would this be?

30. In the dry season, at Spring Tides, rising to 17 feet above datum about 5 hours, at tides rising to 14 feet above datum about 3 hours.

31. The Nimtollah and Colootollah main Sewers joining in one in the Circular Road, would not this limit or diminish the amount of flush water admitted into each from the River?

31. It is by no means necessary that they should be simultaneously flushed.

32 If other purposes would be equally well answered, might it not be as well to have each main sewer single and undivided from beginning to end, so that if need were, it might be flushed with as much water even as it could contain if necessary, thus cleaning it more effectually and avoiding risks from excess of water perhaps admitted as in the other case?

32. They are single and undivided, so far as the discharge of storm-water is concerned, the Nimtollah sewer having an outlet into the Canal at Manicktollah Bridge, to make the two sewers in Nimtollah and Colootollah entirely separate for other purposes, would be an unnecessary expenditure of money I think, as I believe the sewer may be kept clean without it. Apart from the extra expense, there would of course be no objection.

33. Some parts of the Northernmost portion of the City appear to be distantly situated from the nearest main sewer, *viz.* the Nimtollah one, and their drainage, consequently insufficiently provided for?

33. Though not shown so on the Map, the extreme Northern part of the Town may be drained into the main sewers if desired. The ground being high there, admits of the drainage from a small area being

discharged into the River by a constant outfall (or only with a small and occasional impediment from the rise of the tide), and that not being an important part of the River for the mooring of ships, admits of the discharge there without injurious effects. I have thought it may be advisable to relieve the Receiving Sewers of this portion of the drainage during storms, by discharging it at once into the River, but as I have before said, it can be connected with the Nimtollah sewer by other sewers with a good fall, *viz.* 6 feet per mile.

34. Will not the second Northern main sewer in your plan provide for the drainage and rain-fall of the Northern half of Calcutta?

34. No, the Colootollah sewer alone would be insufficient for this purpose. The Nimtollah sewer is absolutely necessary. This sewer (the Nimtollah one) would discharge during storms only into the Canal near the Manicktollah Bridge.

35. How many square miles is that, according to Simms' and to your measurement?

36. And what should be therefore the capacity and dimensions of such sewer, at the junction at the bottom of Colootollah?

35 & 36. I think these questions originated from the assumption that there was no outlet into the Canal at Manicktollah Bridge, for the Nimtollah sewer.

37. Would not such sewer be above the level of the ground in the Circular Road, at the spot indicated especially, *viz.* bottom of Colootollah, where Simms' level gives 20·78 above datum?

37. The invert of the sewers at the place mentioned above datum is 9·0
Diameter of sewer and thickness of work ... 9·25

Deduct this 18·25
from the surface level ... 20·78

Gives ... 2·53 ft.

of cover, which is sufficient.

38. To what extent would the existing small drains be interfered with by your system; would the whole be remodelled, or would any portion remain as it is?

38. In laying the new drainage, the greatest care would be necessary to preserve intact the present drains—wretched as they are they arestill important—till the new ones could be made to receive them. If the work

is properly arranged, this would be very soon after they are interfered with. It is not necessary the entire system of drainage should be completed before the main arteries, or even portions of them, come into operation.

I consider the whole must be remodelled eventually, and that it would not be economy to complicate any general arrangement by endeavoring to make it fit what is allowed to be so very imperfect. In places, however, where these small drains are intercepted, as they will certainly be, by drains *deeper* than themselves, they can be made to discharge their contents with proper precautions at the inlets into the new sewers, and remain in action till more urgent requirements than their re-construction are attended to.

39. How, as to the River Bank drainage; would that remain as it is, or would it be altered?

39. Yes; entirely remodelled.

40. By your proposed plan, the interior of the blocks, which must be the source of much of the filth of the Town, are not provided with any flushing system. Do you not consider it highly desirable that they should be?

40. Highly desirable, and as mentioned in the answer to Question 23. So they might be, as the drains are extended to those places. I must here add that this small water supply now proposed is not intended to be the water supply for Calcutta; it is intended to provide for keeping the drains clean almost exclusively, but it is also intended as a practical illustration of the advantages to be derived from a proper water supply.

II.

SEWERS.

QUESTIONS BY COMMITTEE.

1. YOU are acquainted no doubt with the scheme of drainage proposed by General Forbes, *viz.* to have a Canal running nearly North and South through the City, accompanied with two main

ANSWERS BY MR. CLARK, C. E.

1. YES, as given in his evidence before the Fever Hospital Committee in 1837, and I wish to speak with due respect of any proposal which emanated from so eminent a man; but the whole question of sewerage and

sewers, one on each side of it, which are to be flushed out by the water in the Canal obtained from the River at high tide, and stored up therein ?

drainage of Towns within the last ten years has undergone a very great change. During this period, I have had some years of experience, my time being exclusively devoted to this subject, and I have therefore acquired an intimate knowledge of what is now considered to be an improvement on the old plan in England. I shall therefore, with this explanation, probably be considered less presumptuous in differing in opinion from so eminent an Engineer as General Forbes. His plan was to have a Canal through the centre of the Town, from Chitpore to Park Street, with sewers on either side of it, laid at a dead level 3½ feet below the highest level of the Salt Water Lake. This would be 9·8 — 3·6 = 6·2 feet above datum. From about Middleton Row, the Canal was intended to take an Easterly direction to the Salt Water Lake. Its total length would therefore be about 6½ miles, and with the exception of a short interval at the time of extreme low water in the Canal, it would be incapable of discharging its contents. If connected with the *Lake water only*, (which I believe does not fall lower than 8 feet 10 inches above datum), there would constantly be a depth of 8·81 — 6·16 = 2·65 feet throughout the whole length of this 6½ miles of sewer, which would be below the out-fall level; and if connected with the *Canal*, apart from the *Lake*, then its out-fall would not be constant, but *intermittent*, which I consider absolutely destructive to the perfect action of any general system of Town drainage. The collateral sewers would discharge into still water in the main sewer for at least 8 hours during each Tide, and deposit would inevitably take place, the ultimate removal of which would depend entirely upon the flushing power provided, and which I think even

2. One of the advantages, General Forbes said, of main sewers so situated, would be, that they would bisect all the natural drains of Calcutta running naturally from West to East, that one-half of them only therefore, *viz.* the Eastern half, would require their present direction of fall altered, and that having a shorter distance to run, their slope could be made steeper than with main drains arranged in any other manner, that slope being as much as 12 to 20 feet in a mile. His original plan was for reservoirs in the North part of the Town, to serve the purpose of flushing, the Canal being an after-thought. He also proposed two aqueducts, which were to flush collaterally into these main sewers, the aqueducts passing down the River Bank on the West, and the Circular Road on the East of the City. What is your opinion of this arrangement and project?

the expensive arrangement proposed by Colonel Forbes would fail to accomplish. Such a system of sewers could never, under any circumstances, be *self-cleansing*.

2. General Forbes's plan, which refers to the construction of a Canal through the centre of the Town, I think now is inadmissible, from the consideration that the cost of the surface alone for the construction of the proposed Canal and Sewers would amount to 14 lakhs of Rupees. I do not think there are any advantages to be derived from the North and South positions of the main sewers. The view I take of this matter is to reduce the question to total length and *total fall* from any given spot within the drainage area. Distributing this latter dimension as may be most advantageous, and that system which provides generally the shortest runs to an out-fall, for the whole area will then, so far as fall is concerned, be the best arrangement. This I consider will be best attained by giving the main arteries an East and West direction. If they are to be laid at a *dead level*, and at the depth recommended by Colonel Forbes, I think the East and West direction then would be decidedly preferable, as the drains would have a shorter run to an out-fall, and the means of escape would be more numerous, which would reduce the sizes necessary to be given to these main sewers.

Colonel Forbes estimated his falls from East and West to his main sewers, evidently from the *surface of the ground* at its highest point to the *bottom of the sewers*. I am not certain whether he intended his to be a system of open sewers, the price of which he estimated then, *viz.* Rupees 1,15,315, for 21 miles of sewer, or about one rupee per foot, would lead to that assumption; but if *covered* sewers be intended, then, at their

upper ends, the collateral *main* sewers will be sunk 5 feet as a minimum depth, in order to allow of falls from the capillaries of the system, and this amount must therefore be deducted from their total fall. So far as the falls of the collateral sewers are concerned, I therefore see no advantage in Colonel Forbes's arrangement.

I should fear to lay any considerable length of sewer at a dead flat, as is here proposed, for the main sewer 6½ miles long, or even for half that distance. If any length of sewer so laid be admissible at all in a general arrangement, it should be near the out-fall, where the concentrated rush from other main sewers would overcome the tendency to stagnate from want of fall in that level portion. Now a circular sewer 8 feet diameter, with a fall of 24 inches per mile to an unobstructed out-let, will, if running 1 foot 6 inches deep, have a velocity of 115 feet per minute, and if running 2 feet 6 inches deep, will have a velocity of 143 feet per minute. At every inlet from the branch sewers of larger fall, an additional velocity will be acquired by the main stream, and if a velocity be attained of 150 feet per minute, that sewer will *keep itself clean.* For these reasons, as I have before said, I think when Calcutta is properly supplied with water, special arrangements will not be necessary for flushing, and in the mean time, the River, with a small additional assistance, such as I have proposed, will be ample, without the construction of special reservoirs for this purpose.

A *constant out-fall,* which is not provided in the arrangement now under consideration, is I consider of the highest importance to any arrangement for drainage, and a constant tendency of the currents *in one direction* is I think also indispen-

sable to prevent the deposit which is likely to occur by discharge into the still water, and this still water would be sure to occur at regular intervals, if the influx and reflux of the Tide be permitted within the sewer, and more especially, if the sewer be laid, as is here proposed, below the level at which it could ever be expected to run off all its contents, by being lower than the out-fall, level.

To the further construction of aqueducts, I think very little need be said—it is a relic of an age, when cast-iron pipes were unknown. The limited height to which (by this mode of distribution) the water is available, also limits the area to which it can be applied, or if the aqueducts be so elevated as to overcome this difficulty, so far as area is concerned, then the space occupied by them will stop up the entrances to buildings, and occupy a proportion of the area of the streets, so large (in the narrow streets especially) as to be exceedingly inconvenient, a very large proportion of the water conveyed in these brick constructions would be (as is the case with the present aqueducts) no doubt lost by leakages.

For these reasons, I am not of opinion that the late General Forbes's arrangements for the drainage of Calcutta were the best that could be devised.

3. What do you think of the following modification of it, to separate the two main sewers, and instead of making them pass side by side down the same line or central street, to pass one down the Chitpore Road and the other down the Circular Road, and to arrange the aqueducts, or rather water at high pressure in pipes, as proposed by you, in three lines between them, *viz.* one down the River Bank terminating in the Fort, another down Cornwallis'

3. This, and the four following questions, are intended to compare two several arrangements for the drainage of Calcutta. I am not so wedded to the plan I have proposed as to attempt to defend it one instant, if I see another arrangement which would be an improvement.

It appears to me, therefore, first desirable to fix the leading features of the plan, *viz.* the amount of rain-fall to be provided for the best position, and level for the out-fall sewers, and afterwards to consider

Street, the centre of the City, and the third down the Circular Canal Road, as shown in the accompanying plan?

how best to make the total fall available under these conditions.

I have given my opinion in the Report, that 9 feet above datum is the best level for the out-fall; in these questions, 6 feet 2 inches above datum, as I understand it, is suggested; this greater depth, in my opinion, is not only unnecessary, but would be pernicious, if adopted *within* the drainage area, as it would, I think, ensure the silting up of the sewers—in fact it would be an *intermittent* out-fall from three sewers, varying from 3 to 3½ miles long, laid at a dead level.

The sacrificing of the constant out-fall, and as a consequence ensuring silt in these mains, would secure better falls to the collateral sewers at the *Northern extremity of the Town only;* but I am certain from experience, that an inclination of 5 feet per mile as a minimum is sufficient, with a good supply of water, to keep such sewers clean. Any additional fall, which can be given, is therefore unnecessary, but if it can be attained without sacrificing the efficiency of any other part of the system, there is no objection to it further than the *increased cost* of the work at greater depths, which it in some measure engenders; but if, as here proposed, it be attained by the sacrifice of all pretension to self-cleansing action, then I think it highly pernicious, and I should fear to adopt such a plan.

Question 5-1 and 5-2, as I understand them, contemplate the two large main North and South sewers as laid at a dead level, by which certain advantages would be derived to the collateral sewers, and by which arrangement alone, those advantages could be secured; but in Question 5-3 is the following:—

"The river mouths of the main sewers might, if it be deemed desirable, be raised."

This of course alters the condition altogether. If these be raised, the "steeper falls" would be diminished by as much as this was raised; thus, if it be raised 6 feet to give these sewers—which are more than 3 miles long—a fall of nearly 2 feet per mile, of course the falls of all the collateral sewers would be diminished; but first presuming that these sewers are laid flat, the objection to this, so far as the sewers are concerned, are similar to those I have given in my reply to the last question, as to want of fall and unnecessary depth. Here, in fact, the latter objection is stronger, as the sewers at the end of Sobha Bazar will be 17 feet 10 inches deep, and it would for the whole length of Chitpore Road be 15 feet 10 inches deep. Undoubtedly good falls may be given to collateral sewers falling into such a sewer as this. The difficulty of constructing the sewers would be increased with the depth, and the Chitpore Road is probably not the most desirable place wherein to carry out a work of this formidable nature: those I have proposed there vary from 6 to 9 feet deep only, and all have falls of 12, 6, and 5 feet per mile. I think therefore the level arrangement is wholly inadmissible.

2ndly. Assuming that these sewers have the same levels as those I have recommended, *i. e.* 13 feet above datum at the Northernmost or Nimtollah sewer, at the River end, and 9 feet at the Entally Canal.

The lengths, as proposed in this plan for these three main sewers, will be as follows:—

Circular Road Main	8½ miles long	4 feet fall.	
Chitpore Road Main and Dhurrumtollah ..	3¾ miles long ..	4 ,,	,,
Lower Circular Road	3 ,, ..	3 ,,	,,
Total length 10¼ miles,		11 feet total fall	

As proposed by me the mains are

Nimtollah,	3¼ miles long	..	4	feet	fall
Colootollah,	2¼ „	..	3	„	„
Dhurrumtollah,	1¾ „	..	3	„	„
Lower Circular Road	3 „	..	3	„	„
Total length 10¼ miles,			13 feet	total fall	

Here then is general advantage of 2 feet in the total fall; the length of run to the out-fall is in all cases less; two additional outlets are obtained into the River; and all that part of the Town, extending from Sukeas' Street in the North Division to Kyd Street in the South, comprising one-half the total drainage area of the Town, has the advantage of better falls of nearly 1 foot per mile, while the North and South extremities of the area are equally well provided for.

The arrangement of the pipes shown on the small plan, *viz.* one main from Baug Bazar down the Chitpore Road to the Fort, one along the central road, and a third on the banks of the Circular Canal, for supplying the water, with the exception of the last-mentioned main pipe, appears to be one of the arrangements which might be adopted in the event of Calcutta being well supplied with water. But the relative position of the sewers and pipes conveying water under pressure is by no means material, as the water supply to be effective presumes that water will be available on any spot required. What I have proposed is not intended for a water supply for general purposes, but would be sufficient for watering the Roads, and with the present aqueducts is intended chiefly to keep the public sewers clean. But for every consideration, both of health and comfort, it is desirable that a perfect and abundant supply of water should be obtained, and in operation, as soon as the sewers are provided for conveying off the waste and drainage, which will then so largely increase,

instead of leaving it to stagnate, and evaporate, and to increase largely one of the two elements of malaria, filth and moisture.

4. Main sewers so arranged would not exceed in total length the length of those proposed by you?

4 The main sewers would be of the same length as shown in the reply to the last question.

5. Would they not have these advantages?

Viz. 1*st.*—That falls of collaterals into them would be shorter and steeper?

5-1. Unless these three main sewers be laid at a dead level, none of the collaterals would be *steeper*, and with the exception of a very limited portion at the North end of the Town, they would in no case have shorter runs.

If laid at the same levels at the extreme ends as those proposed by me, then, in the *Southern* Division, the case will be precisely the same as in my proposed arrangement; but in the *Northern* Division, the collateral sewers will have *longer* runs and *less fall* than as I propose, because one of the three sewers is laid at the *margin* of the area. As proposed by me, the mains all *intersect* it; the length of the collaterals considered generally in this other arrangement must therefore for this reason be larger and the fall less steep.

2*ndly.*—That all such collaterals would be well flushed into the main sewers, and all parts of the City be in this respect equally provided for?

5-2. The amount of water-power provided regulates so far the flushing power.

The relative position of the main pipes conveying water under pressure, and main sewers, has really very little to do with question of flushing. The power, which is not stated here, whatever it may be, would be equally efficacious in the one case as the other. As the centres of the blocks of buildings are all to be provided with water, it makes no difference to the *supply* of *water*, what *direction* the *sewers* which *carry* it off take. I therefore do not see that superior advantages for cleansing the sewers are to be expected from this arrangement.

3*rdly.*—That the river mouths of the main sewers might, if it were deemed desirable, be raised, and that

5-3. If the River mouths be raised, as I have before said, any advantage gained to the collaterals by making the main sewer

the sewers themselves might be made of smaller section at their upper ends, and therefore be cheaper—for instance, an area of $1\frac{1}{2}$ square miles is drained by the first mile and a half of your Nimtollah sewer, and the same area in the other case would be drained by two sewers, each of which might therefore be made smaller, while their length, from commencement at the River up to a corresponding point, being $3\frac{1}{2}$ instead of $1\frac{1}{2}$ miles, the upper portions near the River might be of a smaller and a diminishing section?

flat is lost by so much as this is raised. I have thought, that 13 feet above datum is the greatest height which can be given to ensure a power of flush from the River.

If the area of the sewers be contracted at their upper ends, they would of course diminish the power of the water for flushing by contracting its quantity proportionately to the diminished section, but it would also diminish the capacity of the sewers there for receiving, conveying, and discharging storm-water, when the sewers may be expected to be nearly or quite full; and suppose *no* discharge be permitted from the upper end into the River, then to convey the quantity of water I consider it necessary to provide for, *viz.* ·25 inch in depth per hour, these sewers must be of nearly double capacity at their lower ends, and they must therefore either be sunk deeper, increased in number, or be made as open sewers.

6. Is your Nimtollah main sewer, between the Chitpore and Circular Roads, intended to be carried under the present houses and huts?

6. The Nimtollah main sewer would, in some cases, be carried under houses; these, with one or two exceptions only, are all of an inferior character. According to the Map, twenty-four pucka buildings of all kinds, chiefly godowns, and forty huts only, would be affected. These would not all require removal, and might be restored where affected; but it would be better, though *not necessary* to the drainage, to leave the space cleared, and open out a street there.

7. Are you of opinion that, with reference to difficulties of construction and joining on of collateral sewers, the circular and egg shapes will be the best to adopt in preference to sewers with straight sides, and curved bottoms?

7. I have no doubt that the egg-shaped sewers are preferable in every way, the straight sides and curved bottoms are more expensive and less efficient: it is the form for years adopted in the Westminster Division of the Metropolis of England, and years since rejected, in favor of the egg-shape. Circular sewers are less efficient in their self-cleansing properties than egg-shaped of equal capacity, for *varying* quantities

of water; but they are much more efficient than upright-sided sewers; and for strength, equal areas, both of section and capacity being considered, there is no doubt that the circular form is much the strongest that can be adopted for a subterranean construction, *when the soil is homogeneous*, such as Calcutta, excepting in cases where tanks, &c., have been filled up, and there the soil is loose and it would be necessary to lay a platform; but these are the exceptions to the rule.

The difficulties of construction in England are not greater in one form than in the other, and may be easily surmounted by experienced superintendence here.

8. Do you consider 1 foot 3 inches a sufficient thickness of brick-work for your largest sewers in so loose a soil as Calcutta?

8. Where the soil *has been undisturbed*, 1 foot 3 inches is sufficient in firm ground; where it is *loose* and *impossible* to cut to form, I should preserve the internal shape and thickness of invert and crown, but strengthen the sides half or a whole brick in thickness, as the case might require. In ground absolutely *made*, such as tanks filled up with conservancy rubbish, it would be necessary to lay a platform, and give an extended flat base to the whole, and make the construction self-supporting.

9. In the Fever Hospital Committee's Report, there is a Table of levels, page 48, prepared from the levels of Major Schalch, Captain Prinsep, Colonel Forbes, Majors Blechynden and Taylor, in which the level of the lowest part of Calcutta, Muchooa Bazar, is marked as × 8½ feet, while the level of Kyd's Guage or Dock is said to be 7 feet 9 inches. This would make the total height of Muchooa Bazar above Kyd's Dock sill 16 feet 3 inches, while Mr. Simms gives it as 17·84. The difference being 1.59 feet; can you explain this?

9. Impossible to say, without levelling. Probably, one levelled on the crown of the *road*, and another on some low space of ground by its side. I have no doubt that Simms' levels are generally correct.

10. Is not the scale attached to the Municipal Commissioners' small Plan, published with your Report, incorrect, according to their large Map?

10. The Map and Scale is copied from one in the Fever Hospital Committee's Report; it is used simply as a diagram. Upon examination I find that the Scale is not correct; 3 furlongs on the Scale should be half a mile. I have taken no dimensions from this Map, therefore no inaccuracies result from this.

11. How do you arrive at the calculation in para. 15 of your Report, *viz.* 466 feet sectional area of discharge of your four main sewers?

What is the open Canal you refer to in the same paragraph as a sewer, also the "large open sewer" in paragraph 15?

11. This is an error, it is intended to represent that $8 \times 8 \frac{2}{\times} . 7854 = 402 \cdot 24$ superficial feet of area considerably exceeds that of the single channel alluded to in para. 10, *viz.* $40 \times 8 = 320$ superficial feet.

The open canal or sewer, as recommended by the late General Forbes is referred to in para. 11 of my Report.

II

"WATER."

QUESTIONS BY COMMITTEE.

1. The extent of your water supply is 5½ miles length of pipe, is it not?

ANSWERS BY MR. CLARK, C. E.

1. The length of pipe proposed is 29,040 feet, about 5½ miles, which would be in connexion with the aqueduct in the Chitpore Road, Circular Road, and College Street, and give a better supply of water to those parts of the aqueduct which are now imperfectly supplied, in consequence of their distance from the present Engine, as the Public Drains are extended to the interior of the Blocks Pipes will require to be laid to their upper ends for the purpose of cleansing them.

2. This, together with the supply of water now derived from the Chandpaul Engine, will be the full extent of the City water supply: will it not?

2. Yes, that will be the extent of the public supply, exclusive of the Tanks.

3. To what extent is the water from the present aqueducts now used for flushing purposes?

3. Rather difficult to say. This question will be better answered by the Surveyor. I believe the only regular flushing which is done is in the neighborhood of Government Place, Wellesley Place, Council House Street, and a few other streets in that loca-

lity; but the quantity of water which escapes from the aqueducts, and runs through the covered tunnels, must be very considerable. The Engine works about 20 hours during the 24, and lifts above 358 cubic feet, or 2,240 gallons per minute; very little of this water is used before 6 A. M., or after 6 P. M.; therefore, there are 8 hours, during which the Engine is either storing up water, or it is running to waste. If the Reservoirs were quite empty, they would contain the water which the Engine would pump during 4 hours; but the Reservoirs are never empty, and they now are nearly half filled with silt; there can be, therefore, no doubt, that a very large quantity of the water escapes by leakages; this leakage water either saturates the soil adjacent to the aqueduct, or escapes by the covered drains, which are no doubt kept in a somewhat better state than they would otherwise be from this circumstance.

4. What is the length of the aqueducts supplied by them?

4. The total lengths of aqueducts in the different Streets of the Town are 69,520 feet, 13·1 miles. A detailed statement of this is annexed.

5. The more distant parts of these are not always kept supplied: are they?

5. The more distant parts are not well supplied with water, this is, I think, chiefly attributable to the leakages.

6. Is the amount of the water in them sufficient to allow of a liberal flush in the parts of the City to which they extend, supposing good drains to exist?

6. In para. 27 of my Report, I have explained this; it is therein contemplated that the aqueducts should be put into *perfect repair*, *i. e.* the leakages should be stopped. I think, if this was done, nearly half the water now lifted by the Engine would be available for cleansing the sewers. This would not be a *liberal* flush, but I believe would, with care and attention, keep the drains clean. It would not be necessary that the drains should be simultaneously flushed. An apparatus, called a flushing door, would be fixed near many of the junctions of the sewers, by the aid of which

certain lengths of sewers could be made to store up the water for a few hours, for the purpose of flushing other lengths, when the operation may be required; and I think, the drains could, in this manner, be kept clean.

7. Would not some portion of the dirtiest or worst parts of the City, as for instance, along the River Bank at the back of the Mint, and between Wellington and College Street and the Circular Road, be indifferently flushed or cleansed?

7. All the sewers I have marked on the Plan could be flushed by the means provided; as sewers are afterwards extended to other places, so must the means for keeping them clean.

8. Are the present aqueducts and water supply of any use in cleansing the drains?

8. The present aqueducts and water supply are of use, as explained in the answer to Question No. 3, though not in the most desirable manner; it would be necessary to stop the leakages, and regulate the discharge (which is now accidental and dependent on the imperfection of the aqueducts) in order to secure the full advantages of the present water supply

9. What prevents the water from these aqueducts, which amounts to about 2,500,000 Gallons daily, from having a better effect than you state?

9. The quantity lifted is said to be about 134,400 Gallons per hour, or 26,880,000 Gallons per day; but as explained in the last answer, I think the leakages diminish very considerably the available quantity.

10. What effect would be produced by making pucca, or, in other words, brick bottoms, or invert, for open drains?

10. They would be in a measure improved, but they would not be proper channels for conveying away the house drainage; in fact, it would not be desirable to let any such filthy water enter any open drain, and therefore one of the main objects of drainage would be entirely defeated; moreover, they would present such deep chasms in the roads and streets, as to be highly dangerous.

11. Could this be done as opportunity offered by funds available and built in such a manner as to be capable of being covered in, if required and made into a regular egg-shaped sewer?

11. The work for such portions as were first constructed would require to be made thicker, and the double operation would therefore be more expensive. I think, even if such a proceeding be possible, it would be very inexpedient to adopt it.

REPLY No. 4.

Length of Aqueducts of the different Streets.

	Length.	*Total Length in Feet.*
Chitpore Road to Dwarkanauth Tagore's	3,268	
Chitpore Road to Churruckdangah	1,905 6	
Ditto to Burtollah Tank	1,250	6,423 6
Chowringhee Road		3,675
Chandpaul Ghaut to Esplanade Row		6,600
Dhurrumtollah Street from ditto to Circular Road ..		6,500
Circular Road from Dhurrumtollah to Elliott's Road ...	4,246	
Ditto from Boitakhannah to Rustomjee's	5,043	9,289
Radha Bazar to Pollock Street	605 6	
Ditto to Moorgheehatta	1,467	2,072 6
Moorgheehatta Street		872 6
Portuguese Church Lane		325
Esplanade Road to Tank Square...		2,460
Government House, 2 sides	910	
Ditto ditto West	183	1,093
Tank Square to Clive Street		1,850
Ditto to Boitakhannah, Circular Road		6,830
Lall Bazar to College Square		4,760
Park Street from Chowringhee to Wood Street ...		2,480
Wellesley Street from Dhurrumtollah to Wellesley Tank		2,255
Park Street to South Colingah Street		1,220
Wellington Street		2,569
Jaun Bazar Street		5,495
College Street		1,915
Wellesley Place		836
69,520 Feet in 13-1 Miles ...		69,520 6

III.

QUESTIONS BY COMMITTEE. ANSWERS BY MR. CLARK, C. E.

"SEWERS."

1. Do you consider a fall of 2 feet per mile sufficient for the main Sewers?

1. Yes, to a constant out-fall, and if an abundant water-supply be provided, I think the main Sewers proposed would be kept clean without flushing, and in the mean time the tide from the River will effectually flush them out.

2. Your main Sewers have not so much fall as this in the whole, have they? For instance, the Nimtollah Sewers is about 3¼ miles long and its fall 4 feet only instead of 6½.—The Colootollah Sewers 2⅜ miles long and its fall 3 feet instead of 4·9?

2. They are so arranged; the Nimtollah Sewer is intended to be at a level for the whole length of Nimtollah Street, half a mile in length; it would be desirable, if the surface and out-fall levels permitted, to avoid this; but I think they do not; to lift it higher would be to destroy to that extent the falls of the collateral Sewers into it, and to prevent the frequent flushing from the River; as it is intended to allow storm-water to escape from the Sewer into the River, the level portion will not then be objectionable, and a good rush of such storm-water would cleanse it completely; moreover, with the proposed Water Works, it would be possible to flush this length of the Sewers into the River as often as it might be found desirable. From the East end of Nimtollah Street the Sewer would have a fall of 2 feet per mile for the distance of 2 miles to the junction with the Colootollah Sewer; the remaining portion of its length, about ¾ of a mile, would be on a level; this is objectionable if it could be avoided; but I do not think it will be in this position a matter of great importance, as this length of Sewer will receive the united discharge of two main Sewers, which receive in their course minor streams of greatly increased fall and velocity. I think the combined rush of these waters through that length of Sewer to a constant out-fall, will keep that length of Sewer clean. If

the general conditions permitted it, a greater fall would be desirable; but, all things considered, I do not think this level portion can be avoided, without entailing a greater difficulty in some other part of the system.

3. Presuming the out-fall at Entally to be a fixed point depending on the level of the Salt Water Lake, and which consequently is incapable of alteration, would it be possible to raise the other ends, *i. e.*, the River mouths of the main Sewers, so as to increase the fall?

3. Increasing the height of these main Sewers at the River end would improve their falls; but it would be at the expense of the fall in the collateral mains, which would be thereby diminished; it would also diminish the quantity of water during the dry months of the year which would be available for flushing these Sewers from the River.

I have endeavoured so to arrange them that when an abundant water supply is obtained, they shall have the minimum of fall, which will insure their self-cleansing action, and give to all the other Sewers the best falls which this arrangement will admit of; I therefore do not think that it would be advisable to raise the ends of the large Sewers, so as to increase their fall.

4. You have stated that the Nimtollah main Sewer is in a certain part of its course, *viz.*, when the new Street would have to be made above the ground level, and that would then have to be covered in, that is, the surface of the City would have to be raised to cover in the Sewer. This would be still more the case, would it not, if the mouths of the main Sewer were raised in order to make the fall greater?

4. Yes, if the sizes of the Sewers be maintained, lifting them higher would, of course, bring them so much nearer the surface, arranged as I propose. I think for the most part they will have sufficient cover.

The Nimtollah Sewer in that part extending from the East end of Nimtollah Street to Circular Road, will probably be so deep as to have its top about level with the surface and would require to be protected by covering with earth.

If the new street there be carried out, this would, of course, be done for the purposes of the street apart from the drainage in order to keep its surface dry, and above the surrounding flat ground, the excavation from the Sewer above would raise the sur-

face 2 feet high for a width of 25 feet which would make the Sewer perfectly safe.

5. Taking the fall of your collateral drains also at from 9 to 12 feet per mile, or 1 foot in 440 at the most, as shown by the levels, and in your Table of Sewers, such a measure would injuriously diminish their fall into the main drain, would it not?

5. The collateral main Sewers shown, on the plan have all falls varying from 5 to 12 feet per mile; these are Sewers which would receive a smaller class of street Sewers in their course, and may be called sub-mains. The smaller street Sewers would in all cases have falls of 1 in 500 as a minimum, and allow of falls from the house drains and private premises of 1 in 120 as a minimum, while in many cases even these good falls would be exceeded; by lifting the main or receiving Sewers these falls would, of course, be diminished.

It is of the highest importance to secure good falls in the capillary drains, and it is generally found that when the house drains keep themselves clean, if the main drains have a constant out-fall, they will constantly be clean also.

6. As far as the flush from the River is concerned, do you think it would matter if the mouths of the drain were a foot or two higher?

6. I think to put the mouths of the drains at the River end two feet higher would cut off the effective flushing power of the River for four months of the year, which it is by no means advisable to do.

7. Even this would not, however, give the 2 northern main Sewers so much as 2 feet a mile fall?

7. The Nimtollah Sewer would require to be lifted 2 feet 6 inches higher, and the Colootollah main would require to be 1 foot 6 inches higher to give a fall of 2 feet per mile throughout the whole length.

8. Would it be possible to diminish the size and general capacity of the Sewers toward their mouths?

8. To diminish the capacity towards their upper end, would, as I have said before, diminish their power to discharge storm-water into the River, and diminish the amount of flushing water obtained from it; to remedy the first objection, the Sewers would have to be increased in capacity at their lower ends, so that expense would not be saved, the latter objection would be remedied by a larger artificial flush.

9. You have stated, we believe, that the Engine to lift the sewage at Entally would be employed only during the dry months, and that in the rainy season the Sewers would empty into the Balliaghatta Canal, would not this be objectionable, both as regards that Canal and the Circular Canal which it joins, considering the increased quantity of detritus and sewage generally which might be then supposed to be in suspension in the contents of the Sewers. Would not this cause silting up and probably nuisance?

10. Would not the Escape Sewer at Nimtollah be open to the same objection and liable to cause silting up in the Circular Canal?

9 and 10. I do not think any nuisance need be apprehended from storm-water and the detritus which it conveys; the only apprehension I should have would be with reference to the deposit of the detritus in the Canal, as I have elsewhere explained. This would be in a larger measure intercepted in the Street Cess Pits, and be daily removed therefrom during rainy weather. Whatever system of drainage is adopted, the final and complete removal of this matter will present the chief difficulty; if the internal arrangement of the system insure its removal from the Sewers to the out-fall, I think the main object will be gained, as it will be much easier to deal with it in any other place than in the Sewers. I consider that the Silt Pits would intercept the larger quantity. The operation of the Reservoirs near Chandpaul Ghaut Engine is a good illustration of that which may be expected from the Street Cess Pits and the Silt Pits at Entally during the rainy season.

The River water, more or less muddy, is poured by the Engine into this Reservoir, which is 6 feet deep. The watering season commenced in November last, and this Reservoir is now two-thirds filled with silt, not withstanding the water is pumped into it 20 hours during the 24, and is constantly running out.

If any silt should nevertheless pass off into the Balliaghatta Canal, it would there be productive of little injury, as very few boats navigate that Canal; and I understand it has been in contemplation to fill it up. The removal of the silt would, therefore, be comparatively easy in the dry season, and if it is found to be necessary the Silt Pit can be afterwards extended.

A similar arrangement might be adopted to prevent the detritus from entering the

Circular Canal near the Manicktollah Bridge. This would be an easy and inexpensive provision, as that Escape Drain is only required to be used during the rains. I believe that the present Sewer there conveys as much of such matter now as the proposed one would under the new arrangement; it is, however, desirable to prevent any detritus entering the Canal if it can be prevented.

During the dry season, when the road detritus will not enter the Sewers, the amount of silt will be very trifling, and nuisance may be prevented when cleansing the Entally Silt Pit occasionally in the manner I have before alluded to in my reply to Question No. 20.

11. What description of operations do you propose for lifting the sewage into the raised culvert at the end of the Balliaghatta Canal?

11. There are two forms of apparatus by which the Sewage might be lifted a height of 6 feet;—either by scoop wheels or centrifugal pumps worked by a Steam Engine.

12. Do you apprehend any danger from pumps being choked from the semi-fluid character of the contents of the Sewers?

12. If the ordinary form of Suction Pumps be here intended, the objection to their use is the scouring of the pump barrels in consequence of the more or less gritty fluid which would pass through them;—the wearing out and repair of which in this country would be inconvenient and expensive; centrifugal pumps and scoop-wheels are both to be preferred in this respect.

The centrifugal pump has the advantage of being easily adoptable to varying lifts which, when it becomes necessary to empty, the Silt Pit would be very advantageous; up to a lift of 12 feet. I believe this is the most economical apparatus which can be adopted

Its disadvantages are the higher velocity at which it works, and the wear of the axles and bearings which in this country it would probably be inconvenient frequently to renew under all circumstances; I think that one or more scoops wheels would, therefore, be the best apparatus for lifting the drainage.

I think the term semi-fluid is scarcely applicable to the ordinary Sewage; it is, more correctly speaking, dirty water, but perfectly fluid, as much so as the water of the River Hooghly, and there would not be the slightest difficulty in pumping it.

13. Are you aware of any instance where the pumping or lifting of Town Sewage on a large scale has been successfully accomplished?

13. I have seen pumping works in action both at Edinborough and Glasgow for lifting Town Sewage. In both these cases the works were put up by private parties for lifting the Sewage for the purpose of irrigating land. In the former case the Sewage is lifted 15 feet by the ordinary section pump; in the latter it is forced to an elevation of 100 feet by force pumps. I have seen the pumping of liquid manure in Mr. Mechi's farm at Tiptree, Essex, where not only is all the manure from the pigs, sheep, cows, horses, &c., pumped, but dead animals themselves are put into the manure tank. The manure, in this instance, is diluted with water, and conveyed through iron pipes under pressure, and delivered by hose, and yet in precisely the same manner that water is discharged for extinguishing fires and watering streets. The two former of these pumps had been working for some years, and the latter nearly two years when I saw it, and in all these cases with perfect success. I have also seen the works at Leicester, where the experiment was in progress of fixing the fertilizing properties of the Sewage in the shape of a solid manure. All the pumps were then acting perfectly; nearly all the Sewers had been laid for draining the Town, and these were, I believe, so arranged as to require pumping at the out-fall.

The Metropolitan Sewage Manure Company, a few years since, put up works for lifting Sewage 75 feet high, and for distributing it through 15 miles of pipes. The delivery of the Sewage, through the pipes,

was perfect, the Company, however, failed as a commercial speculation. The Cess-pools of London and Paris are almost entirely emptied by hand-pumps. Sewerage works at Selby and Hull were in course of execution when I left E..gland. The latter were laid out and commenced by myself. In both these cases, pumping at the out-fall was intended, with the consent of the General Board of Health, and the approval of the arrangement by their Engineer.

It was at that time (1854) also in contemplation to prevent the discharge of sewage into the Thames; the entire sewage of London was to be collected in a large sewer leading to the Deptford marshes, where a powerful engine was to lift it into another sewer, by which it would be discharged into the Thames below Woolwich. This was the plan, I believe, of Messrs. Walker and Cubitt, Engineers.

There cannot be the slightest doubt as to the applicability of machinery for the purpose of lifting sewage.

14. Are you acquainted with the working of drainage wheels in some of the few districts, and are you of opinion that this machine would be applicable to raising sewage matter as in the present case?

14. I have occasionally seen these wheels in operation in Cambridgeshire and Lincolnshire. I have also seen a very powerful centrifugal pump working at Whittlesey Mere, near Peterborough, which had worked without a single stoppage for repairs during two years. I believe that either the scoop wheel or the centrifugal pumps would be applicable to lifting sewage in this country when the lift does not exceed 12 feet.

15. Would not this method be more economical than pumping?

15. Scoop-wheels are very generally adopted for small lifts, such as 6 to 8 feet, and are considered far more economical than the ordinary form of pump in such cases.

The centrifugal pump has only been brought into use during the last five years, and for similar and small lifts *is*, I believe, considered still more economical. It, however, rapidly loses this advantage, as the lift increases above 13 feet.

16. Can you state what is the average level of the ground between the spot where you propose to fix your lifting engine and the deep part of the Salt Lake?

16. The level where the engine would be fixed is about 21 feet above datum, and by Prinsep's levels, the average bed of the Lake is 6·3 above datum and the lowest bed 4·3.

By this, therefore, the fall from the surface, when the engine would be fixed to the average bed of the Lake, would be about 14·9, and to the lowest bed of the Lake the fall would be about 16·9.

17. The bottom of your sewer, which is to convey the pumped sewage matter, being on an average feet above datum, would it not be above the ground level required, raising by earth-work or brick-work, and consequently be expen-

17. For the first mile of the total distance to the Salt Water Lake, I do not think this sewer would be above the ground level, as its invert would be laid at 13 feet 6 inches above datum at its upper end.

I have taken no regular section for this purpose; but by the levels I have taken, I feel certain that nothing more than the excavated earth would be necessary to cover this sewer, and that little or no extra expense would be incurred on this account. For the remainder of the distance, I think nothing more than an open cut, banked on both sides with the excavated material, would be necessary; there would be no great expense necessary for this work.

18. Reverting to the flushing of the main sewers, you propose the invert or floor at the upper end to be 12 feet above datum, as the tide rises in springs 21 feet: would you not have a head of 9 feet at the end of the sewers at the River?

18. Yes, it is said occasionally to rise to that height, and then there would be 9 feet in depth of water pressing on the sluice at the River end.

19. What provision do you propose for regulating this head of water, so as to prevent so great a rush of water as might injure the sewers, or in case of any accident happening and the falling in of the sewers to prevent the possibility of any part of the town from being submerged?

19. The usual form of Iron Pent Stock would be fixed *at* and near the River end of the sewers in duplicate, so that if one failed, a second would be available for protection against such a catastrophe as is here suggested. It is desirable to have this double protection, but I have known many instances, where even greater pressures are not similarly guarded, a second Pent Stock within the sewer where it is not easily approached, worked by a key from the surface above, or by a side entrance for the purpose (which

may be kept locked) is ample protection from the danger of inundation.

These pent stocks or flushing gates would be self-acting, or otherwise at pleasure, so as to permit water to run out; but would only admit water in large or small quantities as required. The best provision against the falling in of the sewers will be to take care that they are properly built.

20. Do you apprehend any real danger from such a cause?

20. Not the slightest. There are numerous instances of this; the greater part of the Surrey side of London would be under water at high spring tides, if the sluices at the out-falls into the river failed. Hull is a precisely similar case.

21. You state the cost of a main sewer of a barrel shape to be Rupees per 100 feet, are you prepared to state, cost of excavation and cost of brickwork the 100 cubic feet, and if so, what are they, and do you consider them sufficient?

21. The prices for the construction of a circular sewer are—

Brickwork, ...	Rs. 16 per 100 feet
Excavation for sewer invert 8 feet deep,	Rs. 8 per 1,000 ft.
10 feet, ...	Rs. 10 0 0
12 feet,.....	Rs. 12 0 0

This includes excavation, setting timber to support sides of trench, filling in, ramming, and removing surplus soil, which will, for the most part, be required for filling up open drains.

Timbering is estimated as soondry and other rough stuff, including sawing, at 1-8 per cubic feet; and it is presumed that it may be used six times.

Pumping—the principal difficulty will be met with in constructing the first length of sewer, from which, in wet ground, large quantities of water may have to be lifted, as the surrounding soil becomes thereby drier. These difficulties disappear, and then the pumping is much reduced. I have, however, put upon the whole length of sewer, the price which would here pay for pumping out a trench cut in this soil, which is similar to ground whereon I have constructed sewers in England. I presume that at each "face" of work, at

least 6 feet in length, may be constructed per day, and I have considered that the pumping required for this length of 6 feet, at 8 feet deep, will be 5 hand pumps
10 feet „ „ 6 „ „
12 feet „ „ 7 „ „
The working of these pumps are estimated at 9 per day each.

I have no doubt that this will considerably exceed the cost of this part of the operation; but to be safe, I have put this price on the entire lengths of these sewers.

My estimate for circular sewers at various depths is as follows :—

Sewer, 7 feet diameter, 100 feet length, 8 feet deep—

Earth-work, 9,800 @ 8		78 6 4
Timbering	...	81 9 0
Brick-work 32·4 × 100, 3,240, @ 16 per 100	...	517 5 3
Pumping	...	50 0 0
		728 4 7

10 feet deep—

Earth-work, 12,100 @ 10	...	121 0 0
Timbering	...	136 0 0
Brick-work	...	517 4 0
Pumping	...	57 0 0
		831 4 0

12 feet deep—

Earth-work, 14,500 @ 12	...	174 0 0
Timbering	...	163 0 0
Brick-work	...	517 4 0
Pumping	...	64 0 0
		918 4 0

Sewer, 8 feet diameter, 100 feet length 10 feet deep—

Earth-work, 13,300 @ 10...	133	0	0
Timbering ...	136	0	0
Brick-work, 36·3 × 100,363 @ 16	580	14	0
Pumping ...	57	0	0
	906	14	0

12 feet deep—

Earth-work, 15,900 @ 12	190	12	9
Timbering ...	163	0	0
Brick-work ...	580	0	0
Pumping ...	64	0	0
	997	12	9

22. Have you any suggestion to make as to the best plan for insuring a due supply of bricks of first-rate quality for these sewers—quality of Calcutta bricks being generally inferior, as the clay is impregnated with saltpetre?

22. I think the best plan would be to make them, specially for this work, on the nearest available site to Calcutta by water carriage, where the clay is of approved quality; and considering the magnitude of the work, it would be desirable to have an establishment expressly for the purpose of making the bricks and providing the other materials.

23. What kind of mortar or cement do you propose—Sylhet lime or Ghooting lime?

23. Ghooting lime, which I consider equal to, if not superior, to the best cement used in England for the purpose.

24. Independently of its cheapness, or leaving cost out of consideration, do you consider the circular or barrel-shape for your large 7 and 8 feet sewers the best construction?

24. Yes; I do, under the circumstances; the depth in most cases offering a very small margin for cover, and because greater capacity is obtained. The circular, form *where the ground is firm*, is undoubtedly the strongest which can be adopted with the same quantity of material. Where the ground is not of uniform character, the work must be strengthened according to circumstances. Had there been greater depth, I should have been inclined to propose the egg shape for these large sewers also, with a rather larger radius in proportion than that proposed for the other egg-shaped sewers, as this would somewhat im-

prove their self-cleansing action by concentrating the flow, where the quantity of sewage is small.

25. A large part of the ground being what is called made ground, and not a good or firm foundation, would not a flat base or floor of brick-work, with an inverted arch, upright side walls, and semi-circular top, such as this section, be a stronger form for so large a sewer or culvert on soft ground?

25. I am not aware, that a large part of the ground, under the street surface of Calcutta, *is* made ground, and if it be uniformly firm at a depth of 4 to 6 feet, then this form is the best in the excavations I have seen in Calcutta. The ground in the dry season is of good quality, and with proper care would work well.

The Gas Company's Gasholder Pit, situated in a low part of the Town, was made in a soil which stood admirably when the first few feet at the top were removed.

If the ground were so very bad (which I do not think is the case seeing that the houses appear to stand well upon it if at all well built), I should still prefer the *internal* form I have suggested. The upright side walls cannot be stronger than curved ones containing an equal quantity of materials; all that is necessary to the construction of the circular or egg-shaped sewers with success is that the bottom 4 or 5 feet in depth of the excavation should be so homogenous as to cut to a regular form.

26. In connecting the smaller or egg-shaped sewer, would you have any difficulty in making the junction with the large barrel drain?

26. No, not if the material and workmanship are good. At these places, it would be necessary to strengthen the work. The only difficulty in such cases would arise from the small amount of cover in some cases where these junctions occur, which would be overcome by strengthening the work.

27. The principle of your scheme is not dependent altogether on the shape of the main drains, whichever cross section would be the best for cleansing, would be the most durable, cost least money in repairs, and be most easily connected with the subsidiary or minor drain; would be the best—would it not?

27. That from which, after it was completed, would best answer the purpose intended would be the best; upright-sided sewers and junctions at right angles, even if more easily to construct, certainly ought not in my opinion to be adopted; but these circular main sewers are not the *only* form of channel which might be adopted for carrying off the

drainage. An upright-sided sewer *would do* it, I think, less perfectly, and at greater cost; two smaller egg-shaped sewers would also carry away the drainage; but it would be, I think, an unnecessary increase of expense.

The principle of this scheme is not, however, dependent on the circular form of these main sewers.

28. The two silt receivers are each 300 feet long, 25 feet wide, and 6 feet deep—would not the continual flush from the three main sewers always keep the contents of these pits in motion, and prevent any great deposit of silt from taking place?

28. No, I do not think the motion would prevent deposit taking place. I have instanced in another place (answer to Questions 9 and 10) the reservoirs into which the Chandpaul Engine discharges the water pumped from the River. A very large portion of the silt is deposited in these reservoirs. It would be the same with the silt pits I propose, if not found to be of sufficient length, which experience alone would show, they could be afterwards lengthened.

29. What quantity of water do you consider will pass from the silt receivers into the Circular Canal; will it be limpid or impregnated with feculent and sewage matter?

29. The water which would chiefly pass into the Canal would be the *rain water* of storms. This would not be limpid; but I do not think it would be thicker than the ordinary river water in the wet season. Some feculent matter would, no doubt, be present, but I think in very small proportion, at such times, that it would scarcely be perceptible.

30. Have you ever heard of any complaints respecting the odour of the waters of the Circular Canal during the dry season, for if, as asserted, that during March, April, and May but very little of the sewage of Calcutta is passed off into the Circular Canal, do you apprehend any bad odour or effects arising from passing the water of the silt receiver into the canal?

30. I have not heard the complaints alluded to; but I have no doubt the outfalls of the sewers into the Circular Canal are offensive, and very likely complaints are made.

Of course the sewage water during the dry months would be offensive, and particularly so, till an abundant water-supply dilutes the offensive matter.

Then, however, I think, even the flushing from the River would not be necessary, for estimating the quantity which Mr. Simms proposed for a daily supply as *delivered during six hours*, it would amount to 3,373 cubic feet per minute. The quantity in the dry season, when no road detritus was pre-

sent would, I believe, run off completely, the sewer would at such time be self-cleansing, and then no portion of drainage would run into the canal, and nuisance could not thereby be produced. To lift this quantity into the 5-feet circular sewer at Entally a total lift of 6 feet would require a 40-horse engine power; but as this quantity will not be available at first, I have proposed that a 20-horse power engine be erected, and the additiona power required could hereafter be supplied when necessary.

It is, however, very desirable, so as to arrange that this valuable auxiliary power shall be available as required even under those more favorable circumstances.

In the mean time, the assistance of flushing water from the River will be necessary, and so much of it as would be in excess of the power of the engine to lift would run over into the canal for two or three hours at high water, and would contain more or less of feculent matter. This overflow, it would, without doubt, be advisable ultimately to avoid, either by making a separate cut to the Salt Water Lake, so as to be independent of the Canal altogether, or by putting up at once double the engine power, proposed, so as to lift the flushing water also; but I have preferred—all circumstances considered—to avoid this expense at the outset in order that this difficulty may be better overcome when its real magnitude is known.

IV.

QUESTIONS BY COMMITTEE.

1. WITH regard to the full extension of your system of drainage through all the narrow streets of Calcutta, what kind of drains do you propose to carry through the interior streets of the blocks, the lanes, and small streets.

ANSWERS BY MR. CLARK, C. E.

1. I PROPOSE that all the streets in the interior of the blocks should have covered drains, of sufficient capacity, to receive both the storm-water and house drainage of the locality, and that surface channels should be provided to receive and conduct the rain

water through the Gullies or Cess Pits into the covered sewer; in the approximate Estimate I have given for these subsidiary drains, all this is provided for. As the streets are very crooked, it may be desirable not to lay the street sewers in all cases in the exact line of the street, but to straighten their courses as far as practicable.

2. Will such drains require to be double, that is, on both sides of the street, or will they be covered, and under ground, and under the centre of the street?

2. One covered drain for each street will of course be sufficient, and in narrow streets, where there are houses on both sides, it would be placed under the centre of the street.

3. Into these, is it proposed that all the sewage from the houses should run through earthen-ware pipes, or will any portion of it pass off superficially by surface drains?

3. Yes, it is intended that all the *house drains* shall be pottery-pipes: they are more economical than small brick drains, and doubly efficient. If every house be provided with a drain, as it should be, then there will be no necessity for the filthy drainage matter to pass off by the surface drains.

4. Do you propose that any of these under-ground street sewers should be only earthen pipes, and will these, in your opinion, be sufficiently capacious?

4. Yes, some of these street drains may be earthen pipes; some hundreds of miles of public street sewers have been laid in London in similar positions, and with such falls as those here intended. Manchester is almost entirely drained by them. The limit of the application of this form of sewer is when the cost of the pipe is equal to that of the brick sewer, and as the pipes rapidly increase in cost with the increase of their diameters, pipes of large diameter are inadmissible; probably, it would not be desirable to use a pipe of larger diameter than 15 inches, which would cost, at English prices, about 14 annas per foot running. The annexed Tables, showing the quantities of water discharged per minute from different areas during a fall of rain, $\frac{1}{4}$ inch in depth per hour, and the quantities discharged from various pipes, at different inclinations, will show at once that their capacities are ample in such situations; thus, a pipe 15 inches in diameter, with a fall of 1 in 480, will dis-

charge 181 cubic feet per minute; this would be the quantity, falling on about 60,000 square yards, upwards of 12 acres, while a 6-inch tube, with a fall of 1 in 120, will discharge 31·7 cubic feet per minute, which is the quantity calculated at ¼ inch per hour for 11,000 superficial yards, upwards of two acres, and considerably larger than the generality of compounds in Calcutta.

Table No. 1.

Calculation ¼ inch rain fall per hour. On 1,000 *superficial yards, the quantity per minute will be*

$$\frac{3 \times 3 \times 1{,}000}{4 \times 12 \times 60} = \frac{100}{30} = 3\ 125 \text{ c. feet}$$

per minute.

Discharge from

1,000	Supfl yards	= 3 125	c ft p	minute
2,000	,,	= 6 250	,,	
3,000	,,	= 9 375	,,	
4,000	,,	= 12 500	,,	
5,000	,,	= 15 625	,,	
6,000	,,	= 18 750	,,	
7,000	,,	= 21 875	,,	
8,000	,,	= 25 000	,,	
9,000	,,	= 28 125	,,	
10,000	,,	= 31 250	,,	
11,000	,,	= 34·375	,,	
12,000	,,	= 37·500	,,	
13,000	,,	= 40 625	,,	
14,000	,,	= 43 750	,,	
15,000	,,	= 46 875	,,	
16,000	,,	= 50 000	,,	
17,000	,,	= 53 125	,,	
18,000	,,	= 56 250	,,	
19,000	,,	= 59 375	,,	
20,000	,,	= 62·500	,,	
25,000	,,	= 78 120	,,	
30,000	,,	= 93 750	,,	
60,000	,,	—187 500	,,	

Note.—4 Acres 4840 × 4 = 19,360 square yards

4840 × 12 × 58,080 yards = 12 acres

Table 2 *showing the number of Cubic Feet of Water discharged per Minute through Pipes of different diameters, with varying falls.*

Declivity, or Rate of Inclination.			Diameter of Pipes in Inches			
			6	9	12	15
1	in	120	31·7	87 5	180	314
1	in	200	28·4	78·5	161	281
1	in	240	26 0	71 5	147	257
1	in	320	22·5	62 0	127	222
1	in	400	20 1	56·5	108	198
1	in	480	18·3	50 5	104	181
1	in	640	15·8	43·7	90	157

5. For any given street, or bye-street, then, the detail would be something as follows:—A central egg-shaped sewer 2 or 3 feet diameter under ground; *2ndly*, double surface drains intended for rain water only on each side of the road, with *3rdly*, side passages from these into the central drains; and *4thly*, earthen pipes for all the house sewers, to lead under ground into the central drain?

5. Yes, that is the arrangement, excepting where the brick sewer is replaced by a pipe sewer, and whereas, in very narrow streets, one surface channel would be sufficient.

6. Are the two last included in your Estimate, or how are they to be paid for?

6. The side drains from the Street Cess Pits to the Street Sewer are Public Works, and therefore the cost of their construction is chargeable to the public, and it is included in my Estimate. The House Drains are for the benefit of private individuals solely, and would of course be charged to the proprietors of the houses deriving the benefit.

7. Do you consider the average rate you have taken of Rupees 1-12 per foot running, or Rupees 173 per 100, will be sufficient for these sewers, many of which—if not the greater part—may be necessarily covered, egg-shaped, and brick-built sewers?

7. I do not think that the greater part will necessarily be covered egg-shaped brick-built sewers.

It is evident from the Table above given, that a 15-inch pipe drain is of ample capacity for the greater part of the length of these sewers, and as their inclination will never be less than 1 in 500, and generally more, there is no reason (if they can be manufactured here of good quality as I believe they can), why they should not be adopted.

Now the cost of laying 100 feet lineal of 15-inch Tube, at an average depth of 6 feet, will be as follows:—

Earth-work, 4,000 c. ft., at Rs. 6 per 1,000 ..	24	0	0
½ Timbering Trench ...	34	12	0
Pumping, &c. ...	9	4	0
100 feet lineal of 15-inch pipe, at 14 annas per foot ...	75	0	0
Total, Rupees ...	133	0	0

Or Rupees 1-5-3 per foot lineal.

Now this is the most expensive pipe I propose to use, and it is nevertheless 7

annas per foot cheaper than the average price. The cheapest pipe, as estimated in para. 36 of my Report, would be 8 inch diameter, and the estimated cost of this is 80 Rupees per 100 feet. I consider the average price, Rupees 173 per 100 feet lineal, will be ample for the street sewer.

8. Is it safe to calculate a discharge from your sewers at both ends in the rains, that is, suppose a heavy rain-fall took place during high tide in the river, what would be the result?

8. The sewers would have a constant outlet at the Salt Water Lake at all times. The main receiving sewers would, when full, begin to flow into the river, when the surface of the water in the river was not higher than 19 feet above datum, which is 1·6 feet above average Spring Tides, and consequently seldom reached. In addition to this, it is intended to connect the collateral sewers lying to the West of Chitpore Road with the River whenever practicable. These would be guarded by valves opening outwards only, and as their inverts would never be lower than 16 feet above datum, and their height upwards of 3 feet, the effect would be that, when the sewers are gorged with storm-water, these sewers would also assist to discharge it. This will afford a large measure of assistance at such times; and as I have stated in para. 15 of my Report, I consider it will be safe to estimate, from the enlarged area of outlet thus obtained, that the sewers for the discharge of storm-water will have a constant out-let at both ends.

9. The rate for your *main sewers* would appear from the Estimate, page 96, to be Rupees 5-9 per foot running. From your reply to Question 21 *(3rd set)*, the rate for the *receiving* sewers appears to range from about 7-4 to nearly 10 Rupees; what then is the rate for the *main* sewers or egg-shaped ones; and is the above rate of Rupees 5-9 per foot, an average rate over all both *receiving* and *main* sewers?

9. If the list of proposed sewers at the end of my Report be referred to, it will then be found that the cost of every sewer is given separately, and that this will correspond with the answer referred to.

10. Your reply to Question 17 would appear to indicate a fall of 4·6 feet only in the Entally out-fall, *viz.* the difference between the sewer out-fall at 9 above datum and 13·6 inches, whereas subsequently you appear to intimate a fall of 6 feet—how much do you propose to be the actual lift at Entally?

10. Yes, I propose to lay the 5-feet Circular Sewer at Entally extending towards the Salt Water Lake 4 feet 6 inches above the invert of the main receiving sewers there, *i. e.* 13 feet 6 inches above datum; but the Engine will be required to lift the sewage somewhat *higher* than the *invert*, and I have calculated this extra lift for the entire quantity at 1 foot 6 inches, making the entire lift from the invert of the receiving sewers 6 feet.

11. Do you think the pumped sewage at Entally would have sufficient power to run a distance of 2 miles further to Tengrah, with a fall in that distance of 6 feet only, without giving trouble in keeping the sewer clean, as it would have no flush to help it?

11. I have no doubt of its perfect action. Very much of the silt would be deposited in the receiver near the Engine at Entally, but from the observations recently taken, proving that the surface of water during Spring Tides at Tengrah reaches 11 78 above datum, about 1 foot higher than I have reason to expect, I should be inclined to suggest, that an open cut be made from Entally to Tengrah, so as to avoid the use of the Canal as I had previously proposed, though I would still preserve a communication with it to be used when necessary. I would bring this new cut up to the end of the sewers at Entally with its bottom level about 5 feet above datum. I consider, however, that in order to avoid the silting up of the sewers, the *constant* discharge of the sewage is absolutely necessary, and therefore means should be provided to accomplish this, so as to be entirely independent of extraneous circumstances, such as the rise of the tide, &c. I therefore do not think that this cut will obviate the necessity for the Engine, and I think also the drainage during dry weather should not flow through an open Channel in any thickly populated neighbourhood. I would, therefore, make the outlet of the covered 5-feet Circular Sewer into this proposed new cut, at the distance of a mile or thereabouts from Entally. What I proposed will

be better understood from the annexed Diagram, and I have also marked the levels and shown the sewer as now proposed on the Section herewith returned.

These arrangements I should certainly have proposed as preferable in the first instance, but was deterred from doing so by the desire not to interfere with private property and to avoid the extra expense which it entails.

The general conditions of the out-fall are now ascertained to be less favorable than I had reason to suppose, and this arrangement, if adopted, will entirely obviate all difficulty arising therefrom. The precise direction of this new cut, without careful investigation on the ground, I am unable to fix. I should preserve the fall of 3 feet per mile for this covered sewer, and I have no doubt it would keep clear of deposit.

12. Does the Nimtollah sewer, in the direct line proposed by you, run under any pucka houses, or through any tanks, and have you ascertained the number of these, and estimated for them accordingly?

12. This question has already been answered—No. 6 of Captain Young's concluding questions.

The cost of re-building these premises has been estimated by Mr. Rowe, and is included in the Estimate, para. 38 of my Report, *viz.* Rupees 33,000.

13. Are you decidedly of opinion, that the number of receiving sewers you have provided, *viz.* four, is sufficient for the possible rain-fall, which has been known in some years to be as much as 10 inches to 12 inches in the 24 hours.

13. I am decidedly of opinion, that the four receiving sewers are sufficient. Annexed is a Table showing the daily fall of rain during 19 years, and an abstract of the heavy rains therefrom.

The capacity of the sewers is calculated to provide for 6 inches of rain-fall in 24 hours, supposing that it *all* entered the sewers, which is highly improbable.

The only occasion, during nineteen years, when this depth has been exceeded occurred—

1838, October 19th, when 6·40 inches fell.
1844, August 21st, when 11·73 „ „
1851, October 22nd, when 10·12 „ „
1852, May 14th, when 8·40 „ „

In para. 9 of my Report, I have stated, it is usually estimated in England that "when "the area to be drained is partly urban "and partly rural, and where the land "is under cultivation, the water is absorbed "and detained in cavities, and is more "or less delayed in its passage to the sewers; "and in such cases, about half the quantity "of water may be considered to find its "way into the sewers." Moreover, the amount of evaporation in Calcutta is very great. Without making any deduction for this cause, it is therefore apparent that one-half the total rain-fall, on any one day, has never, during nineteen years, amounted to the calculated capacity of the sewers, and only, on two occasions, has it ever at all approximated to that quantity, *viz.* 6 inches in 24 hours. I consider, therefore, that the capacity provided is ample.

14. Do you contemplate the filth from the public Tatties, and that collected by the Tollah Mehters, being brought into the sewers, or will strict rules require to be enforced to ensure its being carried to the River?

14. If the filth, as produced at the public Tatties, be washed into the sewers, by a sufficient quantity of water, through a syphon trap, it would be admitted, and the Commissioners ought to have power to insist on this arrangement being provided; an enormous amount of nuisance would thus be avoided; any house having properly constructed water closets might also be connected with the public sewers by covered drains.

All that is necessary is to ensure that the night-soil should be admitted with a sufficient quantity of water to keep it in suspension: of course it is not intended to permit the Tollah Mehters to shoot the night-soil they collect into the sewers as a place of deposit. The object to be attained is the provision of properly con-constructed water-closets, with an abundant supply of water thereto, as a general arrangement; the necessity for Tollah Mehters and the disgusting stinks which per-

vades the streets during the hours of night would then be entirely obviated.

15. Is any arrangement in your opinion advisable and feasible for diverting some portion of the rain-fall from the sewers and running it into tanks?

15. I do not think such an arrangement would be either feasible, or advisable, but I think it highly desirable to connect the system whenever practicable with the River and Canal, so as to have the greatest number of outlets possible on the occurrence of violent storms. Tanks could only afford a limited assistance, when once filled during a wet season to the invert level of the sewers. Unless of enormous area, they would be comparatively useless for this purpose.

16. Do your rates make sufficient allowance for carting away the earth excavated in forming the sewers.

16. I believe they do. If the entire amount of surplus earth required to be removed a long distance out of the Town, some addition would be necessary; but this is not the case by any means. Along the greater length of the sewers, a place of deposit would be immediately at hand; and in cases where surplus earth did occur, there would be little difficulty in finding places near for its deposit. The filthy soil annually excavated from the present kutcha drains is eagerly sought after, for raising compounds and low swampy places.

17. If it is not carted away, but used to raise the streets, will not, remotely, the latter be required to be included in the Estimate?

17. If such cases occurred, it would, but there are no cases I believe, except the extension of the Nimtollah Sewer, through a part of the Town, where no street at present exists, that would require raising *for the purpose of the drainage;* and therefore the drainage could not justly be charged with the expense. If the streets require raising for other purposes, then the expense must be charged to the ordinary funds available in such cases.

V.

Questions by Committee.

Have you any objection to give details of your Estimate in two or three cases?

1*st*. Assume an 8-feet barrel drain, with 3 feet earth on top of brick-work, per 100 feet running.

14,300 cubic feet excavating foundations, including props and shores, at per 100 cubic feet.....	@ 2 Rs. - - - - -	286	0	0
2,600 cubic feet road metal lifting and relaying, at per 100 cubic feet.....	@ 1 Re. - - - - .	26	0	0
	Pumping, &c., omitted in Question	64	0	0
3,634 cubic feet brick-work, at per 100 cubic feet..	@ 16 Rs. - - - - -	581	8	0
Total per 100 feet running ..		957	8	0

2*ndly*.—Assume Design No. 2 as per annexed tracing.

14,300 cubic feet in foundation, &c., at per 100 cubic feet.....	@ 2 Rs. - - - - .	286	0	0
	@ 1, Re. 100 cubic feet -	26	0	0
2,600 cubic feet road metal, &c. &c. ..	Pumping and Contingencies omitted in Question - - -	64	0	0
6,000 cubic feet brick-work, &c, at per 100 cubic feet	@ 16 Rs. - - -	960	0	0
Total per 100 feet running.	- , - - - - - -	1336	0	0

Answer by Mr. Clark, C. E.

I have placed against the items, as given in this question, the prices at which I estimate the work could be done, exclusive of the profit which a contractor would require to charge in the event of the work being let by contract.

I do not however consider that the quantities of excavation or metalling to be shifted are correctly stated.

Answer by Messrs. Burn and Co.

No. 260.

1. In reply to your letter under date the 2nd June 1856, the probable expense of constructing sewers for the drainage of Calcutta, according to Mr. Turnbull's Designs Nos. 1 & 2, would be as follows:—

DESIGN No. 1.

14,300 cubic feet excavations of foundations, including props ands hores, at per 100 cubic feet 3 Rs.	429	0	0
2,600 cubic feet road metal lifting and relaying per 100 cubic feet 8 Rs.	208	0	0
3,634 cubic feet brick-work, at per 100 cubic, feet 27 Rs. ...	981	0	0
Per 100 lineal feet, Co.'s Rs.	1,618	0	0

DESIGN No. 2.

14,300 cubic feet in excavations, with props and shores, at 3 Rs. ...	429	0	0
2,600 road metal lifting and relaying, at 8 Rs. ...	208	0	0
6,000 brick-work, at per 100 cubic feet, 27 Rs. ...	1,600	0	0
Per 100 lineal feet, Co.'s Rs.	2,257	0	0

We are, Sir,
Yours respectfully,
(Sd.) BURN AND Co.

CALCUTTA,
4th June 1856.

N. B.—Pumping or baling out water not included in the above prices.

ANSWER BY MESSRS. ANDERSON, WALLACE AND Co.

16, *Strand, Calcutta,*
3rd June 1856.

1. IN reply to your letter of yesterday's date, with the tracing of two forms of sewers, we consider that the barrel sewer would cost about 1,210 Rupees per 100 lineal feet, and the other about 1,800 Rupees per 100 lineal feet. These prices would not include the removal of the superfluous earth.

Yours obediently,
(Sd.) ANDERSON, WALLACE AND Co.

ANSWER BY MESSRS. MACKINTOSH, BURN AND CO.

No. 1437.

Calcutta, 2nd June 1856.

IN answer to your favor of date, we beg to inform you that, according to the present price of materials and labor, the cost of constructing a round drain, as shown in tracing, containing 3634 cubic feet of brick-work in every (100 feet) one hundred feet run, and the top 3 feet below the surface, including excavation, brick-work, shoring and filling in and draining, will be Co.'s Rs. 1,200 per 100 feet running.

Ditto, containing 6000 cubic feet brick-work as above, Co.'s Rs. 1,610 per 100 feet running.

The brick-work to be first-rate, set in mortar of two soorkee to one of ghooting lime.

Your obedient servants,

(Sd.) MACKINTOSH, BURN AND CO.

ANSWERS BY MR. CLARK, C. E.

2. I RETURN the two tracings, with the request of the Committee, that you will mark thereon the profiles of your proposed sewer, silt receiver, and out-fall, from Chandpal Ghaut to Tengrah Creek, at your earliest convenience.

2. I HAVE marked on the two tracings the sections of the sewers as requested.

I wish it, however, to be understood, that the exact direction of the proposed open cutting, and covered 5 feet sewer, extending towards Tengrah are not fixed, and therefore the plan must so far be received as an illustrative diagram.

3. I am desired to ask your opinion on the practicability of lowering your system of drainage for this town either 1 or 2 feet—(*i. e.*) to make the level of your inlet at Chandpal Ghaut either 11 or 10 feet above datum, and level of outlet at Entally 8 or 7 feet above datum, in order to obtain a better flush from the river all the year round, as it appears that during December, January and February, your inlet at Nimtollah, 13 feet above datum would not receive much water. If you consider the plan

3. I hold the opinion expressed in my answers to Questions No. 6 (2nd set of questions), asking why the River end of these sewers should not be a foot or two *higher*, and also to No. 30 of the same set, where I say that when Calcutta has an abundant supply of water, flushing arrangements will be entirely unnecessary if the sewers have a *constant outfall*, according to my first arrangement of the circular receiving sewers.

In the mean time, however, there would doubtless be some positive advantages gained

feasible, what would be the additional expenditure incurred in lowering the whole system either one or 2 feet?

by laying the inverts of the receiving sewers somewhat lower; and if there be no prospect of a water-supply, I would certainly do so, in order to secure a stronger flush through these sewers from the river during the dry months of the year. But I think to *put the other sewers of the system lower* would *be a wasteful expenditure of money*, and that it is quite unnecessary. These sewers have falls varying from 5 to 12 feet per mile, which is sufficient. This allows of the street drains having a minimum fall of 1 in 500, which will generally be exceeded; therefore the fall to this part of the system also is abundant, and I would on no account increase the cost and difficulty of constructing these sewers by laying them one or two feet lower, which would also entail an extra depth to all the house drains hereafter to be connected with them. As there are serious objections to the connexion of these drains, or minor sewers, being made at a greater height than about one foot or 1 foot 6 inches above the inverts of the larger sewers—with which they may be connected.

If the receiving sewers be laid at a lower level, in order to secure a more powerful flush through them from the River, I should propose to alter their form to an oval, according to the tracing herewith appended. This would preserve the crowns of these sewers at the same level as proposed for the 7 and 8-feet circular sewers, which I consider to be desirable, as I should apprehend some danger to them on the occurrence of sudden and violent storms, when it might be expected that these circular sewers, if placed 2 feet lower, as suggested by this question, would be running full to the crown at a high velocity. I would, therefore, avoid this by making a taller sewer, of rather larger capacity. The tracings show sections of oval sewers

to be adopted in lieu of the circular sewers 7 and 8 feet diameter, the inverts would be laid 1 foot 6 inches lower than the bottom level of the proposed circular sewers, and I have estimated that the extra cost of the substitution of these sewers, at the increased depth of 1 foot 6 inches for the 10¼ miles of main receiving sewer, would be Rupees 1,22,772, or an average of about 2-4 per foot running. There would be another advantage from this arrangement, that it would admit of the main sewers being connected with the receiving sewers, with a *fall* of 1 foot 6 inches at the point of junction. The effect of this would be to increase the velocity of the smaller stream at that point, so as to ensure the drainage water entering the large sewer with a *rush*, which will not only increase the velocity of the larger stream, but prevent any tendency to deposit near the point of junction in either sewer.

If this arrangement be adopted, it will be desirable to increase the power of the engine, so as to lift 7 feet 6 inches, instead of 6 feet, as by the former arrangement.

There might also be some advantage in adopting the upright-sided sewer in certain positions, thus from Tolly's Nullah to the Circular Road, and for a short length near the River ends of the receiving sewers, as from being wider at the bottom, they would admit more water for flushing.

4. The observations of the rise, and fall of the tide in the Salt Water Lake now give 11·78 feet above datum high-water and 6·53 feet at low-water. Under these fresh conditions, do you wish to entertain any alteration in the details of your scheme?

4. In my answer to Question 11 of the last (4th) set submitted to me, I have intimated the alteration which I consider desirable to be adopted under this altered condition. I should place gates at the end of the silt pit, again where the covered 5-feet sewer enters the open cut, and again at the outfall at Tengrah Creek, to be used as required. I have been unable, with the

limited time at my disposal, to form an estimate of this alteration. If there be,—as I have understood is the fact,—some idea of closing the Entally branch of the Canal altogether, it may be worthy of consideration, whether it could not be retained for this purpose: gates erected at its junction with the Circular Canal would, in the dry season, admit boats and retain water in this branch during the time of low water: from its point of junction with the Circular Canal, the new cut would thence branch off to Tengrah. If this were adopted, very considerable expense would be saved, and interference with the most valuable property on the other route would be avoided, while the Canal would better answer its present purpose by retaining water during the time of low tides.

VI.

QUESTIONS BY COMMITTEE.

1.—WHAT is the out-fall of the present drainage of Calcutta?

2.—During the dry and rainy seasons, separately, what portion of the sewerage do you estimate may pass off into the Circular Canal, Hooghly River, Tolly's Nullah, is evaporated or absorbed into the spongy soil?

ANSWERS BY MR. J. M. ROWE, SURVEYOR TO THE MUNICIPAL COMMISSIONERS.

1.—IF, by this question, be meant in what direction the out-falls run, I must refer the Committee to the plan submitted to Lieutenant deBourbel, which shows what portion of the drainage of Calcutta is carried into the River, what portion into the Circular Canal, and how much into Tolly's Nullah and to the South-east of the Town.

2.—During the dry season a very small portion of the sewerage matter passes off either into the Canal or into the River. The drains, especially in the North Division, are almost all kutcha, and the matter is chiefly deposited within the drains, the water being carried off by evaporation. Heavy showers during the rains carry off a large portion of the sewerage matter in the directions shown in the plan, but milder falls, during the rains, are not sufficient to flush

the drains, and these become choked, as may easily be seen by the quantity of filth annually removed and carted away.

3.—What form of sewer do you consider the most adapted for Calcutta—the open surface drain, or the covered deep drain?

3.—If water can be obtained in sufficient abundance, a sewer (under-ground drain) will, I consider, be preferable, but unless the water-supply be adequate, and the falls given to the sewers ample, so that no matter can settle, the yearly expense of clearing will be very considerable, and the attendant nuisance beyond calculation.

4.—Do you approve of cess-pools for this city? Are you aware of the existence of any, and have they been considered a nuisance?

4.—Cess-pools are objectionable. They were tried by Mr. MacFarlane, and failed. Those sunk within the Police premises became so offensive, that it was necessary to close them.

5.—What is the formation of the streets of Calcutta; do they run over the natural soil, or made ground? If the latter, at what depth is the natural soil to be found, and describe its nature and quality?

5.—The streets are carried generally over the natural soil. Some constructed by the Lottery Committee passed here and there over old tanks and low ground, but these localities were always well filled up with good soil. If the question bear on the construction of sewers, I consider the soil quite suitable to works of the kind.

6.—Do you apprehend any danger to the houses on either side in inserting a barrel-drain 7 feet internal, 9½ or 10 feet external diameter, along the narrow streets, such as Chitpore Road, Nimtollah Ghaut Street, Cossitollah, at a depth of 12 feet below the surface?

6.—In streets of 20 feet in width, the houses must be shored up before the sewers can be commenced on. The natural soil is every where alluvial, and any easement removed must of necessity create a corresponding sinking on either side.

7.—If so, can you mention any facts that lead you to that conclusion, and in what width of street would you consider it safe in Calcutta to insert a drain of the dimensions and depth above mentioned?

7.—The small sewer running through Raneemoodee Gully, constructed subsequently to the adjoining buildings, caused the whole of the walls to sink, although every precaution was adopted, especially that of constructing the sewer by small pieces at a time. Its depth, moreover, does not exceed 3¾ feet. No sewer could with safety be constructed without shoring the buildings in a street of less width than 40 feet, and then it must be run along the centre.

8.—Give the dimensions of all the outlets of the present sewers of Calcutta, and describe their locality?

8.—The outlets are all shown on the plan forwarded to the Committee. It would occupy much time to ascertain the dimensions required, and I could not undertake to do so, unless relieved from my official duties for some days.

9.—When a heavy fall of rain occurs in this City, how is it passed off? By the present system of drainage, evaporation, or the being absorbed in the spongy soil?

9.—Heavy falls of rain are mainly passed off by the outlets marked in the plan. The soil being alluvial, a good deal of the rain water is absorbed, while evaporation is trifling during the rains. In the native part of the Town, where tanks are numerous, these are replenished by rain water, which is consumed for domestic purposes by the poorer classes, as no other supply is now available.

10.—What do you estimate the cost of a large under-ground sewer, diameter 7 to 8 feet per 100 cubic feet of brickwork?

10.—Good masonry, suitable to the construction of sewers, cannot be executed for less than 16 Rupees per 100 cubic feet.

11.—What is the general declivity of the present drains in Calcutta? Mention some instances.

11.—From 1 to 3 feet per mile, some of the drains have no fall beyond that secured by the body of water running along them. The Dhurrumtollah drain has a fall of 3 feet to the mile; a portion of Camac Street outlet is nearly on a dead level.

12.—What fall in feet per mile do you consider ought to be given in this City for minor drains, main sewers 3 to 5 feet diameter, and receiving sewers 5 to 8 feet diameter?

12.—Three feet per mile will, on an average, be ample for main sewers, but less would be sufficient, if a good supply of water be secured for thoroughly flushing the sewers.

13.—Are any of the streets in Calcutta private property?

13.—Several lanes in the Town are claimed as private property.

14.—From your experience, which do you consider the most healthy part of Calcutta, for Europeans or Natives? Also the most unhealthy; and do you ascribe this to deficiency of drainage, or to what other cause?

14.—I consider the Southern portion of the Town of Calcutta the most healthy on account of the ventilation being better. The Northern division is the most unhealthy, chiefly on account of its crowded unventilated condition, partly because it is badly drained, and also materially because the supply of wholsome drinking water is deficient.

15.—Where, in your opinion, ought to be the out-fall of a general system for the drainage of Calcutta?

15.—The out-fall should be to the Eastward, as the natural fall is in that direction.

16.—Of all the systems that have been propounded, to which do you give the preference, taking into consideration the present circumstances of this City; or have you thought of any scheme different from the rest?

16.—The best and most efficient scheme for the drainage of Calcutta is the one proposed by Colonel Forbes, and is fully explained in the Reports on the Fever Hospital and of the Municipal Committee. Colonel Forbes devoted much time to the mature consideration of the subject; his opinions always carried weight, for they were never hastily given on any point; and the especial recommendation of his plan over all others, I am acquainted with, is that it provides an ample supply of water for flushing all the main sewers.

The plan has been somewhat misunderstood, and if thoroughly examined, it will be found that the proposed Central Canal was neither intended to carry off the surplus rain-water of the Town, nor of any sewerage matter, but solely for the purpose of providing from the River and Lakes sufficient water to flush the two main sewers on either side. Another advantage of the Canal would be to furnish good drinking water during six months in the year.

17. Describe, in general terms, the grounds on which you have founded your opinion in favor of any system?

17. My preferential opinion in favor of Colonel Forbes's proposed plan is founded on its being the only one that provides a sufficiency of water for flushing the principal sewers of the system. It is simple, not liable to derangement, and by no means expensive, as compared with other plans, though the contrary has been urged, especially with reference to the number of new streets it might be necessary to open out. It has been adduced, that the expense of purchasing ground, especially for a central street or opening, would be so great as to counterbalance the advantage, but the fact is lost sight of, that much of the ground that would be purchased being frontage land and included in the Estimate could be at once re-sold to advantage and thus reduce the accepted outlay of Rs.

14,00,000 to about 8,00,000. It will under any circumstances, and independent of any system of drainage, be requisite to open some, if not many, new streets in the Northern Division of the Town, and some in the Southern, for without these no system can be efficient. Take for instance, the section formed by Dhurrumtollah, Bow Bazar, Cossitollah, and Wellesley Street. If main sewers be constructed only along Dhurrumtollah and Bow Bazar (according to Mr. Clark's system the next main sewer will not even be in Bow Bazar but in Colootolah), the centre of that section cannot be properly drained, without opening at least two streets and an ample supply of water, and for this no provision is made in Mr. Clark's system, and all the centres of blocks are similarly situated. New openings, and a water system, must therefore go hand in hand with a drainage system.

Mr. Clark himself says, that "*if* Calcutta were well and properly supplied with water, the sewers, *if* well constructed, would be kept perfectly clean and free from deposit."—*Mr. Clark's System, page* 21, *para.* 27.

18. What do you consider are the difficulties which militate against the proper drainage of Calcutta?

18. The difficulties that must arise in providing an efficient system of drainage are owing to the small amount of fall obtainable on so large a surface of ground.

19. On the other hand, are there any advantages?

19. There are relative advantages, and I can but describe them in the words of Colonel Forbes, who says in his Report:—"Whether the site of Calcutta was originally chosen by accident or design, I consider that in so far as regards the means of drainage, it was *well* chosen, and in support of this opinion, I for the present deem it only necessary to advert to the well known, but most important, fact, that the lowest part of it, situated in the vici-

nity of, and intersected by Muchooa Bazar Street, is on a level 8½ feet, higher than that of the highest surface of the Salt Water Lake.

20. Describe present water supply, quantity, and for what purposes is it made available?

20. The only water supply now available is raised from the River Hooghly at Chandpaul Ghaut by an Engine of twenty horse power. It supplies the existing aqueducts for watering the streets, and assists in filling such of the Public Tanks as are connected with those aqueducts. The water raised by this Engine is also used in flushing daily some of the surface drains recently constructed about Government Place and Tank Square; but the supply is totally inadequate to the flushing even of the main sewers.

21. What is the yearly expense of cleaning out the Entally Pit?

21. This work is done by the establishment of the Superintendent of Canals, and the information required can be obtained in the Chief Engineer's Office.

22. Is it done by means of boats?

22. The work is done by coolies, and the earth on removal thrown down in the neighbourhood.

23. Is clearing by means of boats expensive, more or less so than by other methods?

23. Cleaning by means of boats would be a very expensive operation, as independent of the boat establishment, coolies would be required to fill and empty the boats. The expense must also depend materially on the distance the boat would have to carry the silt.

24. In the poorer parts of the Town, who are the owners of the properties generally, or land-holders?

24. Wealthy natives are principally owners of large blocks of huts. Those sections of the Town occupied by brick-buildings are mostly the property of individual or separate owners.

25. What is the nature of the sewage carted away at Entally? Is the nuisance great?

25. The sewerage matter annually removed from the Entally Pit consists mainly of earth and road washings mixed up with the drippings, washings, and other matter proceeding from private houses. The nuisance occasioned by the removal is very great in the neighbourhood of the

pit, and for many days after the work has been completed.

26. The same regarding the excavated matter in the City?

26. The matter is similar to that removed from the Entally Pit, except at the North end of the Town, where a quantity of cow-dung is allowed to pass into the sewers during the rains.

27. What would be the nature of the sewage under a good system of drainage, with plenty of water supplied?

27. The same as above, with a considerable addition of night soil, it being I believe intended to permit the filth from some public and private privies to be washed into the sewers. But if any system of drainage adopted be not complete as to the supply of water, the nuisance will be materially increased.

28. The drains running into the River are temporarily closed by the tide, are they not? Have you ever to clean these out by manual labor?

28. The sewers running into the River seldom require cleaning, and some have, to my knowledge, never been opened out. The branch sewers communicating with them are cleaned out yearly. One of the disadvantages attending the communication of sewers with the River is that the flowing water at high tides forces all the pent-up noxious vapours out through the gratings and gully holes, but on the other hand, it leaves no silt at the ebb, owing to the high tides occurring at long intervals during the dry season; and the sewer being only occasionally flushed, the nuisance, when the water does come in, is excessive—so great, that it would be preferable to have open drains, from which noxious vapours would escape almost as formed in sewers, where they are pent up for days and forced out in volumes by the in-coming waters.

29. How much of the City at present drains into the River? Do you think that, with the aid of plenty of water to flush, this might be left without alteration?

29. The portion of the Town, which drains into the River, is marked on the plan submitted to the Committee. The drains to the North of Jackson's Ghaut are mostly cutcha and must be altered.

30. This would relieve the drains running towards the Salt-Water Lake of a good deal of the rain-fall they would otherwise have to carry off?

30. With a few exceptions, these drains are not connected with the main sewers trenching towards the Salt Water Lake, and if the whole of the drainage now running into the River and into Tolly's Nullah were allowed to flow Eastward, existing outlets would not be sufficient to carry off the additional waters during heavy falls of rains.

31. Are you of opinion that water should be supplied, or means of flushing given to the centres of the City blocks, that is, as much as possible to the sources of all the sewage, or do you consider that flushing the main and receiving drains will be sufficient?

31. Water carried to the centre of blocks would be of little use as regards the flushing the main drains, but independent of this supply, it will be necessary to flush the main sewers from their head or commencement. By main sewers, I mean not only those running East and West but all those running North and South connected therewith.

32. Will the supply laid on for the Northern part of the City in the system under consideration, *viz.*, Mr. Clark's, be in your opinion sufficient, combined with that derived from the Chandpaul Engine?

32. Mr. Clark's system does not provide any supply of water for flushing the drains generally. He proposes to flush the main sewers from the River at high tide time, but it is doubtful whether even this can be done during the dry season. His main sewers are upwards of 4,000 feet apart, and none of the minor sewers between them can be reached by the River water. In para. 28, he proposes to erect a twenty-horse power Engine at Baug Bazar. He has also included in his Estimate the expense of laying down five and a half miles of nine-inch piping, but as the length of the streets in this portion of the Town, which the Northern Engine is supposed capable of serving, exceeds fifty miles, I am at a loss to understand how the water is to be distributed, as in the Southern portion, the Chandpaul Engine, though of the same power, cannot supply more than water enough for the aqueducts and tanks.

33. How will Chowringhee be situated in this respect?

33. According to Mr. Clark's system, Chowringhee will get no supply of water for flushing the sewers.

34. In the case of a good water supply, how would you arrange the drainage, that is, how much and what part of it would you have surface, and what part covered in?

34. If a good supply of water can be obtained adequate to the flushing of the sewers, I consider them preferable to open drains. If the supply be not sufficient, the sewers will silt up and the expense of cleaning them periodically will be great, and the nuisance considerable.

35. In the case of no water supply, or an insufficient one, how would you arrange?

35. In this case I would recommend open drains as far as practicable.

36. Suppose the sewage of Calcutta properly diluted would be carried into the Circular Canal, and that circumstances allowed of a strong current being passed through this from the River by the Chitpore Locks, which at present is not the case, owing to fear of destruction of the earthy banks, do you think all would be carried off eventually seaward by the Lake deep channel, or would the Canal silt up and become a nuisance?

36. A strong current would certainly carry off the sewerage matter, but it would be objectionable to use a navigable Canal for this purpose, especially as the earth banks must suffer considerable damage from the introduction of any current strong enough to carry off the diluted sewerage matter that might be poured into it, as contemplated by this question.

37. If a similar and separate cut were brought from the Lake up to Entally, and from thence communicated direct with the River by Dhurrumtollah to Chandpaul Ghaut, whence a strong River flush might be derived, as in the case of the Canal itself, and into this all the sewage sufficiently diluted were passed, do you think it might be maintained self-cleansing?

37. Any Canal constructed in the direction proposed must be *faced* with masonry, otherwise the strong current of the River, which would certainly be adequate to the thorough cleansing of the Channel, would speedily destroy the banks of a Canal dug in such a soil as that on which Calcutta is built.

38. Do you think provision might be made for diverting any portion of the rain-fall into the City Tanks, instead of allowing it all to enter the sewers, and thus permitting the sectional area of the latter to be reduced? Do you think this should be done or not, and in what parts of the Town could the rain-water be thus appropriated?

38. I would not recommend the rain-water that falls on the streets being allowed to flow into the Tanks. It would certainly not improve the water; all private Tanks are replenished by rain-water, but the supply is only useable for domestic purposes, when the ground over which it flows into the Tank is kept clean.

39. Are any of the present City Tanks filled with the Chandpaul aqueduct or Engine water? Mention them. Is the water of these used by the population for drinking purposes and approved of?

39. The following public Tanks are supplied by the aqueduct:—Dhurrumtollah, Wellesley Square, College Square, Newgeepookur, Jaun Bazaar, and Burtolla, with some of the Maidan Tanks. The water is drank and approved of, and the people are too thankful for it

40. Are any of the present City sewers of efficient fall and self-cleansing? If so, mention them and the circumstances under which they act.

40. The main sewers connected with the River are self-cleansing, owing to the large flow of rain-water which enters them, and is sufficient to remove the sediment which has accumulated during the dry season. The sewer running along the North side of Dhurrumtollah is also self-cleansing.

41. What are the average general dimensions of the main and minor thoroughfares of the City?

41. From 80 to 50, and as low as 16 feet in width. The average breadth of all the streets is given in Simms's Report in the Survey of Calcutta.

42. What would be the largest dimensions (breadth and depth) of covered drains which you think could with safety be constructed in these streets? Mention the nature of the difficulties and dangers to be apprehended.

42. This depends on the width of the streets through which the sewers would have to be carried, with reference to the difficulties and dangers to be apprehended. *Vide* my reply to Questions Nos. 6 & 7.

43. Is the present nuisance from the Public Tatties great? How many are there in the City, and what measures would be necessary to remove this nuisance altogether?

43. Public Tatties are amongst the greatest nuisances in Calcutta. Besides them, there are places of deposit for night soil removed every morning. Good sewers, properly flushed, would at once put a stop to this nuisance. The number of licensed Public Tatties is 113.

44. You are no doubt acquainted with the different projects which have been from time to time proposed, including those contained in the Fever Hospital Committee's Report? Will you mention briefly such parts of any of them as you deem to merit notice, and any to which you are in preference favorably disposed?

44. This question I consider to have been already answered in my reply to Question No. 16.

45. Would there be any serious practical difficulty do you think in constructing the circular and egg-shaped sewers of the dimensions proposed?

45. There would be no difficulty in constructing egg-shaped sewers, but as the soil is alluvial, a base should certainly be given them.

46. What would you give as the rate, with present market prices, of constructing a seven-feet diameter Circular Sewer, with 15 inches thickness masonry, the top of the brick-work put below the surface, including every thing incidental to it, as excavation, fitting in, ramming down, and removal of surplus soil?

46. I have mentioned the rate per 100 cubic feet in my reply to Question No. 10. A thickness of fifteen inches is not sufficient for a sewer of seven feet in diameter. The contingent charges attending excavation, &c. cannot possibly be given without minute calculations suited to each particular locality.

47. Do you think earthen ware pipes, such as proposed for conveying the house drainage to the underground sewers, would answer in this City, with reference to the habits of the people, or to any other circumstances you may deem of consequence?

47. They would answer, provided the fall were sufficient and a supply of water available for flushing them. If not so sloped and flushed, they will not answer, and cause much inconvenience and expense.

48. Which, in your opinion, and what circumstances, causes the greatest nuisance—covered or an open drain?

48. I have already explained in my reply to Question No. 28 under what circumstances an open drain may cause less nuisance than a sewer.

49. What is the remedy in your opinion?

49. The remedy is a daily and ample supply of water for flushing the sewers: open drains will then be no longer necessary.

50. Why do the City open drains cause so little perceptible nuisance to standers or passers-by?

50. Because the noxious vapours fly off almost as soon as generated. I beg again to refer to my reply to Question No. 28.

51. Then do you deem ventilation by large, or wide openings, between dwellings of importance?

51. If this refer to the ventilation of sewers, the fewer the openings are the better, unless the vapours are carried off by pipes higher than the adjoining houses.

52. You are aware, that in all Oriental Cities, the streets are built narrow, shade and a small amount of cool air, being in the opinion of the natives, preferable to wide, hot streets with plenty of air. Do you consider this principle of any consequence, and how would you reconcile it with a number of new and wide streets opened out?

52. Free ventilation is of as much importance as good drainage, and wide streets are decidedly preferable to narrow ones. The air in narrow streets is certainly much cooler, but cannot be so healthy. The heat and light of the sun are indispensible elements in a healthy locality.

53. How many new streets would you propose to open out, of what dimensions, and in what parts of the City?

53. Several wide streets are required in the native part of the Town, both from West to East, and from North to South. The number of streets required would be best shown on a plan, and I will furnish it if necessary.

54. Do you think any reform could, under an efficient drainage, be effected in the present system of Tanks, so as to make these less numerous, but larger and more wholesome; and is not such a reform necessary to the health of the inhabitants?

54. Good wholesome drinking water is very essential to health, and its want inflicts greater sufferings on the poorer classes than the nuisances by which they are surrounded. The numerous Tanks in the native part of the Town would not be required, if the crowded parts were opened out, Tanks dug for affording good supplies, and a sufficient quantity of a pure beverage made available. The people object to the filling in of the noisome tanks that abound in the Northern division, because they can obtain water from no other source though that is frequently next to poisonous.

VII.

QUESTIONS BY COMMITTEE.

1. TIME of tide, flow and ebb, in hours, at Tengrah and at Dhappa?

2. Section of deep cut between Tengrah and Dhappa, showing depth of water and breadth of channel?

3. Plan and Section of the same required.

4. What is the rate of flow of the current, both at rise and at ebb, in the deep cut and Salt Water Lake passage?

5. Does the present flow of sewage of Calcutta into the Circular Canal cause any nuisance or odour, either in the dry or rainy seasons?

ANSWERS BY MR. GALIFFE, COLLECTOR OF TOLLS ON THE CANALS.

1. THE time of flow and ebb vary so much, that I have sent you my three books for January, February, and part of March 1856.

2. Have not the Drawing required.

3. Have not the Drawings required.

4. Unable to obtain it, not having the requisite instruments.

5. Yes, when the Chitpore Lock Gates remain shut for a length of time, there is not a sufficient current of water to carry off the sewerage in an efficient manner, and it remains floating in the Canal, discoloring the water and causing a most offensive odour.

6. Do you expect there would be a nuisance if the whole sewerage of Calcutta were passed off into the deep passage of Salt Water Lake, either at Dhappa, Tengrah Khal, Manicktollah, or Bamunghatta?

6. Tengrah Khal would do; Dhappa would not; Bamunghatta too far off.

7. Who does the Salt Water Lake belong to?

7. It is private property.

8. Are you aware by what process the area of the Salt Water Lake has been diminished from 40 to 20 square miles since 1830?

8. The area has diminished in consequence of the great quantity of silt washed down with the water passing through the Circular Canal and spreading itself over the surface of the Salt Water Lakes.

9. What is your opinion in regard to the salubrity of Calcutta as affected by the Salt Water Lake: is it improved, or otherwise?

9. I cannot state as to how the Town of Calcutta is affected, but I know that the neighbourhood of the Salt Water Lakes is decidedly unhealthy.

10. Suppose the Salt Water Lake drained and ground under cultivation, would you apprehend any evil effects from the South-Eastern wind coming direct from the Sunderbuns into this Town, without passing first over an expanse of salt or briny water as at present?

10. I certainly think that, if the Lake was drained and the ground under cultivation, it would make the neighbourhood more healthy; but the Lake should be so drained that the water at high tide should not get over it.

11. What is the depth of water at Dhappa, high and low water?

11. The height varies according to the season at which it is taken. (*See* Question 1.)

12. To what height on the Gauge at Chitpore do you allow the tide to flow from the Hooghly in the Canal?

12. Between 14 and 15 feet.

13. Have you made any observations as to the difference of time of high water in the Salt Lake and in the River Hooghly opposite Calcutta?

13. From observations taken, I find that it is high water at Dhappa and Calcutta nearly at the same time, but the tide does not ebb so soon at Dhappa as at Calcutta.

14. Will you state what are the rules and regulations under which you are now acting, as regards the opening and shutting the Lock Gates at Chitpore? that is to say, specify the time when the Gates are opened, and how long they remain open?

14. The opening and shutting of the Gates depends upon the height of water in the River. During the rainy season they remain closed for a considerable period, during the dry season they could always be left open, except during the bores. This however would not be advisable, as it would nearly empty the Canal, and the navigation would be greatly impeded, and which it is necessary to prevent as much as possible.

15. What is the velocity of the streams, under different circumstances, at Chitpore Lock? State *depth of water* and *velocity*, and *width* of *the* opening.

15. The height of the water at Chitpore is regulated entirely according to the season at which it is taken, varying from 1 foot 6 inches to 21 feet 6 inches.

Width of the opening 24 feet 2 inches.

Have no instruments for obtaining the velocity of the water.

16. What is the velocity of the stream, the depth of water, and the breadth of the stream at the

Dhappa Toll House,
At Balliaghatta Bridge,
At Narkaldangah Bridge,
At Manicktollah Bridge,
At Ooltadangah Bridge, and
Dum-Dum Road Bridge,

when the Chitpore Gates are open?

16. Unable to obtain this, having no instruments, and further the Lock Gates are shut and will not be opened for two or three days.

17. If more water were admitted from the Hooghly, would the banks of the Circular Canal be endangered from the increased current of water?

17. If more water were admitted from the Chitpore end, the banks of the Canal would in many places undoubtedly suffer. A matter of still greater importance is the foundations of the Bridges, which would be endangered by the continual admittance of a great body of water.

18. If means were taken to secure the Canal banks from injury, and a much greater quantity of water be admitted, so as to establish a larger stream, both in volume and velocity, would there be a beneficial effect as regards keeping the Canal clean?

18. Too much water in the Canal would prevent boats passing through freely and make the navigation difficult and dangerous. This could not be carried out in consequence of the small distance from surface of water to the Bridges, as large boats would be unable to pass under them. As it now is, it is found necessary to employ men to watch some of the Bridges to prevent accidents.

19. If all the filth of Calcutta were poured into the Circular Canal, and a powerful stream of water admitted from the Hooghly, would the filth in your opinion be swept into the Salt Lake beyond the Dhappa outlet, or would it be deposited in the Canal in whole or in part?

19. My opinion is, that the filth would not be carried away, and that a great portion of it would remain in the Canal. The tides meet a little below Dhappa and run very strong, and it is doubtful whether it would meet with sufficient resistance in a body of water flowing from the Circular Canal.

Abstract of Heavy Rains,

Showing the days on which 3 Inches in the Depth of Rain was exceeded from 1834 to 1852, vide No. 13 of IV. Set of Evidence.

Year.	Month.	Rain fall Depth in Inches.
1834	28th June	3-20
,,	3rd August	5-30
,,	13th August	4-40
,,	6th October	3-20
1835	17th June	3-50
,,	17th September	4-00
,,	19th October	3-40
1836	26th August	3-75
1837	None	0-00
1838	26th September	3-10
,,	19th October	6-40
1839	21st September	4-32
1840	21st August	5-65
,,	22nd August	5-15
1841	1st September	5-92
,,	3rd August	3-19
,,	4th August	3-85
1842	21st March	3-37
,,	21st June	3-50
,,	15th August	4-75
1843	4th June	3-96
,,	9th August	3-27
,,	10th August	1-02
,,	11th August	3-92
,,	16th August	3-12
1844	12th June	3-27
,,	21st August	11-73 to 9-62
1845	29th June	4-91
,,	8th August	3-90
1846	9th July	3-59
,,	17th August	3-27
1847	10th July	3-09
,,	7th November	4-66
1848	20th June	4-07
,,	28th July	3-00
,,	13th October	3-86
1849	28th June	3-08
,,	15th August	4-30
,,	22nd September }	6-38
,,	23rd September }	
1850	13th September	4-68
1851	22nd October	10-12
1852	14th May	8-40

To

W. CLARK, ESQUIRE,

Secretary to the Commissioners.

DEAR SIR,

I HAVE to acknowledge the due receipt of your Report on Drainage, together with your letter of the 22nd of December last, inviting, on the part of the Commissioners, any observation that may occur to me.

That the general imperfect drainage of Calcutta adds materially to the casualties in the City, does not require the Physician's warranty; but the immense mortality occurring among the Shipping, arising chiefly from the drains opening into the Hooghly, is not perhaps so generally known. When I was residing at the Strand Road, I was often called upon suddenly to visit cases of Cholera in vessels subject to the effluvia of the drains, &c. That it depended upon the drains in most cases, there was no question in my mind, as with the change of wind, would the vessel above or below the respective drain be affected, even in the middle of the stream. When the public floating privy was allowed at Baboo Ghat, and a vessel anchored above or below it, so sure was death to deal its fatal blow: with the removal of the nuisance, the fatality vanished. In 1848, I was called up at 2 in the morning by the Commander of the *Robert Bradford* to visit a youth on board his vessel, who he feared had Cholera. I accompanied him to a Ghaut, called Midah Ghaut—the stench was insupportable, and I learnt from him the night carts were emptied there. I enquired where his vessel was lying; on the locality being pointed out, and as the current of air was passing from the East, I said—"Depend upon it, the effluvia is resting over your vessel." So it was. The boy had Cholera. I therefore advised the Captain to send the lad to the Howrah Hospital, and in the event of any more being attacked, to let them follow immediately, and recommended him to have his vessel removed in the morning. I believe before 9 o'clock that morning, five more had been sent to the Hospital, and at 4 in the afternoon the boy and three men were dead. The vessel was removed, and from that time the Commander informed me the sickness ceased. The night carts are not I believe emptied there now, and the mortality I learn has in proportion lessened, but not ceased, as a large drain still opens out there.

The cases I have cited go far to prove the greater mortality occuring in vessels is mainly attributable to the drains opening into the river. I have studied the subject well, and speak from experience, and there can be no question that wherever a drain opens opposite a vessel, that vessel is sure to have a large amount of sickness and mortality. I could cite many cases, but the two mentioned appear to me sufficient to prove that the present system of drainage is not only bad, but affects a large, increasing and important body—sea-faring folks, more than the inhabitants.

Should your Report be carried out, I do not hesitate to say hundreds of lives will be annually saved by its means.

I have the honor to be,
SIR,
Yours obediently,
(Signed) C. O. WOODFORD, M. D.,
Professor of Medical Jurisprudence, and Police Surgeon.

CALCUTTA,
January 2nd 1855.

MEMO. SUBMITTED AT MEETING OF COMMISSIONERS HELD ON THE 18TH JANUARY 1856.

THE *levels of the Salt Water Lake,* as given by Blechynden, Prinsep, Schalch, and Simms, all show the variation of the surface of the water therein to be confined within limits not exceeding 3 feet 2 inches, and when reduced to the Kidderpore Dock sill as a datum, may be represented as follows:—

BLECHYNDEN	Gives highest level in the rains 9 feet, lowest in the dry season 7 feet.
PRINSEP	Gives the mean level as 7 feet 9 inches.
SCHALCH	Gives the highest level in the rains 9 feet 8 inches, lowest level in the dry season 8 feet 10 inches.
SIMMS	Gives the height of the Canal entering the Salt Water Lake as 10 feet 2 inches.

I had understood that the surface of the water in the Canal was connected with the Lake only, the gates at Chitpore being constructed expressly for the purpose of preventing the influence of the tides from being felt in the Canal. This was formerly the case. In order to check the above levels for the purpose of the drainage of Calcutta on the 3rd of October, I took a set of levels to the end of the Balliaghatta Canal, which showed the surface of the water there to be 10 feet 9 inches above datum. The effect of the rise caused by the rains had not then subsided. This, in connexion with the filthy state of Balliaghatta Canal, I considered amply sufficient to account for the difference of 1 foot between this level and that as given by Schalch, and I therefore adopted his figures as accurate. Schalch moreover says, that the tide in the Lake during the dry season is confined to a rise of 10 inches, and that in the rains there is no perceptible tide. This information therefore induced me to give the height 9 feet above datum, stated at page 4 of my Report, as the level of the Salt Water Lake and Canal.

A few days since being at the Canal, I observed that there had been a tide of 3 feet above the height I had before observed, and I then found that it is now the practice, in order to account for the diminished depth of the water, to admit the tide freely from the River, which causes a rise in the Balliaghatta Canal at the time of high water in the River to an extent of about 4 feet. My levels must therefore have been taken at or near the time of low water.

The effect of this upon the system of drainage I have proposed during the time of heavy storms occuring at high water will be a partial interruption of the discharge till the water subsides by the falling tide; but during the dry season will not at all affect the out-fall, as it is proposed to cut off all connexion with the Canal at that time, and *lift* the sewages by an Engine (provided for in the Estimate) and discharge it by a separate channel connected with the Salt Water Lake.

Some modification of the arrangement at the out-fall may probably under these circumstances be made with advantage in connexion with the suburban authorities.

(Signed) W. CLARK.

VIII.

Queries by Committee.	Answers by Collector, 24-Pergunnahs.
1. To whom does the Tengrah Creek or Rajah Khal belong?	1. To Rajah Radhacant Deb, Putneedar, Kallicant Roy Chowdry, and others.
2. Who is the owner of the land in its vicinity?	2. Kallicant Roy Chowdry and others.
3. Who is the proprietor of the Salt Water Lake on either bank of the Creek?	3. Salt Water Lake, within Zemindaree of Kallicant Roy Chowdry and others.
4. A toll is said to be levied on all boats which pass up the Khal—what may be the yearly amount, and what would be the requisite compensation to be granted, if the Khal were occupied for public purposes?	4. No toll is exacted, but it is customary for boats of a large size, *viz.* from 300 to 500 maunds freight, to pay the owner from 3 to 5 annas each, and boats of a smaller size a handful of whatever they may contain, such as wheat, fish, paddy, &c. &c. The annual amount of this fee averages from 300 to 400 Rupees, the owner may have realized more, but the Khal during some months of the year is dry. As to compensation, hitherto, Government has paid for lands taken up for Railway purposes from 15 to 20 years purchase at which rate the amount of compensation would be from 6,000 to 8,000 Rupees.
5. Raja Ghaut, at entrance of the Creek, is a mart for fire-wood and shells for lime. It is small at present, but capable of extension. Were the Khal to be taken up, the Ghaut would lapse and compensation might follow. What would it amount to?	5. The Ghaut, with the land contiguous to it, comprising the wood and lime mart, yields 50 Rupees annually. and is capable of realizing 50 Rupees more, amount of compensation 20 times amount of annual assets when the mart is in its best condition, Rupees 2,000.
6. The fisheries in the Creek, and the adjacent swamps fed by it, are said to be valuable. What may be the yearly produce?	6. Estimated area of fishery 175 beegahs, annual assets at Rupees 2 per beegah, Rupees 350; amount of compensation 20 times the amount of assets, equal to Rupees 7,000.
7. Is the Tengrah Creek private or public property? In the former case, what would be the cost of resuming the Khal to the exclusion of all traffic and passage thereon?	7. Private property. *Vide* Answer No. 1, Cost of excavation from 1,500 to 2,000 Rupees, price of land—estimated area, 450 beegahs—Rupees 4,500. Total amount of compensation from 6,000 to 6,500.

8. What is the price of land on the borders (West) of the Salt Water Lake per beegah?

8. On the West border of Salt Water Lake, 20 Rupees per beegah.

9. What towards the interior of the Lake, separately, for cultivated and submerged land?

9. Water land in Salt Lake 10 Rupees per beegah, Paddy land 20 Rupees per beegah.

10. What is the price of land per beegah from Entally to Tengrah, taking it to be all garden soil?

10. From Entally to Tengrah, garden land, at an average, 600 Rupees per beegah.

11. Further South, about 1 mile, the country is more open and interspersed with fewer tenements, what is the cost of ground per beegah?

11. From Tengrah further South, 200 Rupees per beegah.

12. What would be the expense of taking up 10 beegahs of land at Entally in immediate proximity to the Branch Canal, presuming that at least one-half of such space would be covered with premises, houses, or huts?

12. From Rupees 20,000 to 24,000, for ten beegahs of land alone.

13. What would be the cost of resuming the same area at Baliaghatta, on the North side of and close to the Branch Canal? The map of Punchanundgram Estate shows that there are few buildings in that quarter.

13. From Rupees 5,000 to 10,000 for ten beegahs of land alone.

14. What is the price of land per beegah from Teeljullah to the Salt Water Lake?

14. Rupees 100 to 125 per beegah.

15. What between Manicktollah and Salt Water Lake, separately, for the three widths, *viz.* on this side of Circular Canal; *secondly*, between the two Canals; and *thirdly*, in vicinity of Salt Lake?

15. 1*st.* Rupees 1,000 to 1,400 per beegah
2*nd.* Rupees 200 to 300 per beegah
3*rd.* Rupees 100 to 125 per beegah.

16. If a new street, 1 mile in length and 40 feet in width, be opened out in the heart of the North Division of the City—first, what would be the cost of occupation for one year; *secondly* the price of such land per beegah; *thirdly*, the value of the buildings and premises thereon per beegah?

16. Area 14 beegahs, 13 cottahs, 5 chittachs, 15 krants.

1*st.* Rs. 720 per beegah per annum.
2*nd.* Rs. 12,000 per beegah.
3*rd.* Rs. 4,000 per beegah.

NOTE.

The 1st and 2nd Answers are rather vague, for it is impossible to determine the rent of land with houses thereon, without inspecting every inch of the land and

estimating by measurement the cost of every building thereon.

17. What would 10 beegahs of land along the river bank cost, say between Chitpore Bridge and the Mint, separately, for ground and tenements?

17. Price of 10 beegahs of land, at 2,000 Rupees per cottah, 4,00,000 Rupees. Impossible to determine the price of houses, but considering that a small godown in that locality realizes from 20 to 30 Rupees per mensem, I should say the building will cost another 4,00,000 Rupees.

18. The Committee require data on which to form a rough estimate of the expense of widening a street in Calcutta, say from 25 to 50 feet. Can you furnish them with any information which could lead to an approximate result of the cost of such an undertaking.—As for instance, Moorgyhatta lane, for a length of ½ mile?

18. The price of land is 12,000 per beegah in that vicinity; the price of building houses, &c., would also amount to the same, at which rate the entire cost of undertaking will be about 1,10,400 Rupees.

DRAINAGE COMMITTEE.

APPENDIX N°. VI.

TABLES.

OBSERVATIONS

OF THE

TIME, RISE AND FALL OF THE TIDES,

ON THE

GAUGE OF CHITPORE LOCK,

WHICH CONNECTS THE

CIRCULAR CANAL WITH THE HOOGHLY RIVER;

TAKEN DURING

Portions of the Year 1856.

THE zero of Tide Gauge on sill of Chitpore Lock is said to be at or nearly on the same level with the datum zero of the Gauge on sill of Kidderpore Old Dock. This fact, however, the Committee have not had occasion to verify.

CHITPORE.

Date.	Hour.	Height of water Inside the Canal. Ft.	In.		Height above datum sill of Kyd's Lock.	Date.	Hour.	Outside the Canal. Ft.	In.	Height above datum sill of Kyd's Dock.	REMARKS.
17th April	5½	7	8		..	17th April	5½	5	8	..	Gate closed.
,,	6	7	5		..	,,	6	4	8	..	,, ,,
,,	7	7	0		..	,,	7	3	6	..	,, ,,
,,	8	6	6		..	,,	8	3	0	..	,, ,,
,,	9	6	0		..	,,	9	2	2	..	,, ,,
,,	10	5	9	Lowest water	..	,,	10	4	4	..	Gate open.
,,	11	8	2		..	,,	11	7	11	..	,, ,,
,,	12	9	2		..	,,	12	8	11	..	,, ,,
,,	1	10	2		..	,,	1	9	11	..	,, ,,
,,	2	10	10	Highest water	..	,,	2	9	7	..	,, ,,
,,	3	9	6		..	,,	3	9	3	..	,, ,,
,,	4	7	11		..	,,	4	7	8	..	,, ,,
,,	5	6	6		..	,,	5	6	3	..	,, ,,
,,	6	5	5		..	,,	6	5	2	.	,, ,,
,,	6½	5	3		..	,,	6½	4	3	..	,, ,,
18th April	5½	8	3		..	18th April	5½	6	6	..	Gate closed.
,,	6	7	11		..	,,	6	5	6	..	,, ,,
,,	7	7	5		..	,,	7	4	3	..	,, ,,
,,	8	7	2		...	,,	8	3	0	..	,, ,,
,,	9	6	6		..	,,	9	2	6	..	,, ,,
,,	10	6	3	Lowest water	..	,,	10	4	4	..	,, ,,
,,	11	8	3		..	,,	11	8	0	..	Gate open.
,,	12	10	0		..	,,	12	9	9	..	,, ,,
,,	1	11	3		..	,,	1	11	0	..	,, ,,
,,	2	12	0	Highest water	..	,,	2	11	9	..	,, ,,
,,	3	11	4		..	,,	3	11	1	..	,, ,,
,,	4	9	6		..	,,	4	9	3	..	Gate closed.
,,	5	8	9		..	,,	5	7	4	..	,, ,,
,,	6	8	1		..	,,	6	6	0	..	,, ,,
,,	6½	8	3		..	,,	6½	5	1	..	,, ,,
19th April	5½	8	9		..	19th April	5½	8	1	..	Gate closed.
,,	6	8	4		..	,,	6	6	11	..	,, ,,
,,	7	7	10		..	,,	7	5	0	..	,, ,,
,,	8	7	5		..	,,	8	3	11	..	,, ,,
,,	9	7	0		..	,,	9	3	0	..	,, ,,
,,	10	6	6	Lowest water	..	,,	10	2	2	..	,, ,,
,,	11	7	3		..	,,	11	7	0	..	Gate open.
,,	12	10	11		..	,,	12	10	9	..	,, ,,
,,	1	12	6		..	,,	1	11	3	..	,, ,,
,,	2	13	0	Highest water	..	,,	2	12	9	..	,, ,,
,,	3	12	5		..	,,	3	12	2	..	,, ,,
,,	4	10	6		..	,,	4	10	3	..	,, ,,
,,	5	9	2		..	,,	5	8	5	..	Gate closed.
,,	6	8	7		..	,,	6½	6	11	..	,, ,,
,,	6½	8	3		..	,,	6½	6	0	..	,, ,,
20th April	5½	8	10		..	20th April	5	8	2	..	Gate closed.
,,	6	8	6		..	,,	6	6	11	..	,, ,,
,,	7	8	3		..	,,	7	5	5	..	,, ,,
,,	8	7	11		..	,,	8	4	3	..	,, ,,
,,	9	7	5		..	,,	9	3	1	..	,, ,,

CHITPORE.

Date.	Hour.	Height of water Inside the Canal.			Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside the Canal.		Height above datum sill of Kyd's Dock.	Remarks.
	Ft.	In.						Ft.	In.		
20th April	10	7	0		..	20th April	10	2	3	..	Gate closed.
"	11	6	6	Lowest water	.	"	11	6	0	..	" "
"	12	7	4		..	"	12	11	4	..	" "
"	1	8	6		..	"	1	13	6	..	" "
"	2	8	9		..	"	2	14	6	..	" "
"	3	9	3		..	"	3	13	11	..	" "
"	4	9	0		..	"	4	11	6	..	" "
"	5	8	10		..	"	5	9	4	..	" "
"	6	8	7		..	"	6	8	0	..	" "
"	6½	8	4		..	"	6½	7	5	..	" "
21st April	5½	9	0		..	21st April	5½	8	3	..	Gate closed.
"	6	8	10		..	"	6	7	8	..	" "
"	7	8	8		..	"	7	6	2	..	" "
"	8	8	5		..	"	8	5	0	..	" "
"	9	8	0		..	"	9	4	0	..	" "
"	10	7	8		..	"	10	3	3	..	" "
"	11	7	2		..	"	11	2	2	..	" "
"	12	7	6	Lowest water	..	"	12	10	0	..	" "
"	1	8	2		..	"	1	10	3	..	" "
"	2	9	0		..	"	2	14	8	..	" "
"	3	9	3		..	"	3	14	5	..	" "
"	4	9	4		..	"	4	13	3	..	" "
"	5	9	6	Highest water	..	"	5	10	10	..	" "
"	6	9	1		..	"	6	8	6	..	" "
"	6½	8	10		..	"	6½	7	6	..	" "
22nd April	5½	9	1		..	22nd April	5½	8	8	..	Gate closed.
"	6	8	11		..	"	6	8	0	..	" "
"	7	8	9		..	"	7	6	6	..	" "
"	8	8	6		..	"	8	5	7	..	" "
"	9	8	3		..	"	9	4	2	..	" "
"	10	7	11		..	"	10	3	2	..	" "
"	11	7	5		..	"	11	2	2	..	" "
"	12	7	2	Lowest water	..	"	12	6	0	..	" "
"	1	8	4		..	"	1	11	6	..	" "
"	2	9	2		..	"	2	14	0	..	" "
"	3	9	3		..	"	3	14	4	..	" "
"	4	9	3		..	"	4	13	2	..	" "
"	5	9	2		..	"	5	11	0	..	" "
"	6	9	2		..	"	6	9	2	..	" "
"	6½	9	0		..	"	6½	8	1	..	" "
23rd April	5½	9	4		..	23rd April	5½	9	2	..	Gate closed.
"	6	9	2		..	"	6	8	6	..	" "
"	7	8	10		..	"	7	7	2	..	" "
"	8	8	8		..	"	8	5	10	..	" "
"	9	8	3		..	"	9	4	6	..	" "
"	10	8	0		..	"	10	3	6	..	" "
"	11	7	1	Lowest water	..	"	11	2	6	..	" "
"	12	7	5		..	"	12	7	6	..	" "
"	1	8	0		..	"	1	11	0	..	" "
"	2	8	10		..	"	2	13	3	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal. Ft.	In.		Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside the Canal. Ft.	In.	Height above datum sill of Kyd's Dock.	Remarks.
23rd April	3	9	2		..	23rd April	3	14	5	..	Gate closed.
"	4	9	4	Highest water	..	"	4	14	4	..	" "
"	5	9	3		..	"	5	13	4	..	" "
"	6	9	2		..	"	6	10	6	..	" "
"	6½	9	1		..	"	6½	9	0	..	" "
24th April	5½	9	4		..	24th April	5½	8	10	..	Gate closed.
"	6	9	2		..	"	6	8	6	..	" "
"	7	8	10		..	"	7	7	10	..	" "
"	8	8	8		..	"	8	6	3	..	" "
"	9	8	4		..	"	9	5	1	..	" "
"	10	7	11		..	"	10	4	2	..	" "
"	11	7	6		..	"	11	3	0	..	" "
"	12	7	3	Lowest water	..	"	12	2	6	.	" "
"	1	7	6		..	"	1	10	0	..	" "
"	2	8	4		..	"	2	12	4	..	" "
"	3	9	3		..	"	3	13	10	..	" "
"	4	9	4		..	"	4	14	0	.	" "
"	5	9	3		..	"	5	13	4	..	" "
"	6	9	4	Highest water	..	"	6	11	0	..	" "
"	6½	9	2		..	"	6½	10	3	..	" "
25th April	5½	9	1		..	25th April	5½	10	0	..	Gate closed.
"	6	9	0		..	"	6	9	3	..	" "
"	7	8	10		..	"	7	7	10	..	" "
"	8	8	6		..	"	8	6	4	..	" "
"	9	8	3		..	"	9	5	6	..	" "
"	10	7	11		..	"	10	4	4	..	" "
"	11	7	5		..	"	11	3	4	..	" "
"	12	6	9		..	"	12	2	6	..	" "
"	1	6	3	Lowest water	..	"	1	4	6	..	" "
"	2	7	4		.	"	2	9	4	..	" "
"	3	8	9		..	"	3	12	2	..	" "
"	4	9	0		..	"	4	12	6	..	" "
"	5	9	3		..	"	5	12	10	..	" "
"	6	9	2		..	"	6	11	1	..	" "
"	6½	9	1		..	"	6½	10	0	..	" "
26th April	5½	8	10		..	26th April	5½	11	0	..	Gate closed.
"	6	9	0		..	"	6	8	10	..	" "
"	7	8	10		..	"	7	8	0	..	" "
"	8	8	5		..	"	8	6	11	..	" "
"	9	8	1		..	"	9	5	6	..	" "
"	10	7	10		..	"	10	4	6	..	" "
"	11	7	4		..	"	11	4	0	..	" "
"	12	7	0		..	"	12	3	6	..	" "
"	1	6	4	Lowest water	..	"	1	2	6	..	" "
"	2	6	6		..	"	2	5	10	..	" "
"	3	7	5		..	"	3	6	10	..	" "
"	4	8	8		..	"	4	8	10	..	" "
"	5	9	1		..	"	5	10	5	.	" "
"	6	9	2		..	"	6	10	3	..	" "
"	6½	9	1		..	"	6½	9	8	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal. Ft.	In.		Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside of the Canal. Ft.	In.	Height above datum sill of Kyd's Dock.	REMARKS.
27th April	5½	8	11		..	27th April	5½	10	4	..	Gate closed.
"	6	8	10		..	"	6	9	4	..	" "
"	7	8	5		..	"	7	7	4	..	" "
"	8	8	1		..	"	8	6	4	..	" "
"	9	7	9		..	"	9	5	1	..	" "
"	10	7	3		..	"	10	4	1	..	" "
"	11	6	9		..	"	11	3	2	.	" "
"	12	6	4		..	"	12	2	6	..	" "
"	1	5	11		..	"	1	2	0	..	" "
"	2	5	5	Lowest water	..	"	2	2	6	..	" "
"	3	5	10		..	"	3	5	10	.	" "
"	4	7	1		..	"	4	8	2	..	" "
"	5	8	3		..	"	5	10	1	..	" "
"	6	9	0		..	"	6	10	10	..	" "
"	6½	9	1		..	"	6½	10	11	..	" "
28th April	5½	8	0		..	28th April	5½	8	4	..	Gate closed.
"	6	8	4		..	"	6	8	11	..	" "
"	7	8	10		..	"	7	9	1	..	" "
"	8	8	9		..	"	8	8	6	..	" "
"	9	8	1		..	"	9	7	1	..	" "
"	10	7	10		..	"	10	6	0	..	" "
"	11	7	3		..	"	11	5	0	.	" "
"	12	6	10		..	"	12	4	2	..	" "
"	1	6	6		..	"	1	3	4	..	" "
"	2	6	0		..	"	2	2	10	..	" "
"	3	5	6	Lowest water	..	"	3	3	1	..	" "
"	4	5	10		..	"	4	5	6	..	" "
"	5	6	10		..	"	5	7	7	..	" "
"	6	8	10		..	"	6	7	10	..	" "
"	6½	8	3		..	"	6½	9	4	..	" "
29th April	5½	5	10		..	29th April	5½	5	0	..	Gate closed.
"	6	6	6		..	"	6	6	6	..	" "
"	7	7	2		..	"	7	7	9	..	" "
"	8	8	2		..	"	8	8	6	..	" "
"	9	8	9		..	"	9	9	3	..	" "
"	10	8	8		..	"	10	9	0	..	" "
"	11	8	10	Highest water	..	"	11	8	0	..	" "
"	12	8	5		..	"	12	7	3	..	" "
"	1	7	8		..	"	1	6	0	..	" "
"	2	7	0		..	"	2	5	0	..	" "
"	3	6	2		..	"	3	3	11	..	" "
"	4	5	11		..	"	4	3	2	..	" "
"	5	5	6	Lowest water	..	"	5	3	1	..	" "
"	6	5	10		..	"	6	5	4	..	" "
"	6½	6	0		..	"	6½	6	5	..	" "
30th April	5½	6	5		..	30th April	5½	3	5	..	Gate closed.
"	6	6	1		..	"	6	3	1	..	" "
"	7	5	9	Lowest water	..	"	7	4	6	..	" "
"	8	7	0		..	"	8	6	9	..	Gate open.

CHITPORE.

Date.	Hour.	Height of water Inside the Canal.			Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside the Canal.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.					Ft.	In.		
30th April	9	8	10		..	30th April	9	8	9	..	Gate open.
"	10	9	6		..	"	10	9	7	..	" "
"	11	10	0	Highest water	..	"	11	9	6	..	" "
"	12	9	10		..	"	12	9	10	..	Gate closed.
"	1	8	10		..	"	1	8	6	..	" "
"	2	8	1		..	"	2	7	1	..	" "
"	3	7	9		..	"	3	6	0	..	" "
"	4	7	2		..	"	4	5	0	..	" "
"	5	6	8		..	"	5	4	0	..	" "
"	6	6	4		..	"	6	3	8	..	" "
"	6½	6	0		..	"	6½	3	6		" "
1st May	5½	7	6		..	1st May	5½	4	6	..	Gate closed.
"	6	7	1		..	"	6	3	10	..	" "
"	7	6	8		..	"	7	3	0	..	" "
"	8	6	2	Lowest water	..	"	8	3	1	..	" "
"	9	7	6		..	"	9	7	5	.	" "
"	10	10	0		..	"	10	9	10	..	" "
"	11	11	3		..	"	11	11	0	..	" "
"	12	11	10	Highest water	..	"	12	11	5	..	" "
"	1	11	4		..	"	1	11	0	..	" "
"	2	9	9		..	"	2	9	4	..	" "
"	3	8	10		..	"	3	7	11	..	" "
"	4	8	5		..	"	4	6	10	..	" "
"	5	8	0		..	"	5	5	7	..	" "
"	6	7	7		..	"	6	4	8	..	" "
"	6½	7	5		..	"	6½	4	3	..	" "
2nd May	5½	8	4		..	2nd May	5½	6	6	..	Gate closed.
"	6	8	0		..	"	6	5	6	..	" "
"	7	7	7		..	"	7	3	10	..	" "
"	8	7	2		..	"	8	3	2	..	" "
"	9	6	7	Lowest water	..	"	9	2	7	..	" "
"	10	6	11		..	"	10	8	10	..	" "
"	11	8	2		..	"	11	11	6	..	" "
"	12	9	3		..	"	12	12	2	..	" "
"	1	9	5	Highest water	..	"	1	13	6	..	" "
"	2	9	4		..	"	2	12	5	..	" "
"	3	9	3		..	"	3	10	3	..	" "
"	4	8	11		..	"	4	8	2	..	" "
"	5	8	6		..	"	5	6	11	..	" "
"	6	8	3		..	"	6	5	6	..	" "
"	6½	8	1		..	"	6½	5	0	..	" "
3rd May	5½	8	7		..	3rd May	5½	7	0	..	Gate closed.
"	6	8	5		..	"	6	6	4	..	" "
"	7	8	2		..	"	7	4	4	..	" "
"	8	7	10		..	"	8	3	6	..	" "
"	9	7	4		..	"	9	2	7	..	" "
"	10	7	0	Lowest water	..	"	10	7	0	..	" "
"	11	8	2		..	"	11	12	2	..	" "
"	12	9	3		..	"	12	15	0	..	" "
"	1	9	5	Highest water	..	"	1	15	10	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal.			Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside the Canal.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.					Ft	In.		
3rd May	2	9	5	Highest water	..	3rd May	2	14	10	..	Gate closed.
"	3	9	4		..	"	3	13	6	..	" "
"	4	9	3		...	"	4	10	3	..	" "
"	5	9	5		..	"	5	8	6	..	" "
"	6	9	0		..	"	6	6	11	..	" "
"	6½	8	11		..	"	6½	6	2	..	" "
4th May	5½	9	4		..	4th May	5½	7	6	..	Gate closed.
"	6	9	0		..	"	6	6	4	..	" "
"	7	8	10		..	"	7	5	0	..	" "
"	8	8	6		..	"	8	3	11	..	" "
"	9	8	1		..	"	9	2	8	..	" "
"	10	7	9		..	"	10	3	0	..	" "
"	11	7	8	Lowest water	..	"	11	9	4	..	" "
"	12	8	0		..	"	12	13	4	..	" "
"	1	9	0		..	"	1	13	10	..	" "
"	2	9	6		..	"	2	14	8	..	" "
"	3	9	6		..	"	3	14	0	..	" "
"	4	9	8	Highest water	..	"	4	11	8	..	" "
"	5	9	6		..	"	5	9	4	..	" "
"	6	9	3		..	"	6	7	10	..	" "
"	6½	9	0		..	"	6½	7	0	..	" "
5th May	5½	9	6		..	5th May	5½	8	8	..	Gate closed.
"	6	9	3		..	"	6	8	0	..	" "
"	6	9	1		..	"	7	6	3	..	" "
"	8	8	10		..	"	8	5	0	..	" "
"	9	8	7		..	"	9	4	0	..	" "
"	10	8	3		..	"	10	3	0	..	" "
"	11	8	0	Lowest water	..	"	11	2	6	..	" "
"	12	8	5		..	"	12	8	6	..	" "
"	1	8	9		..	"	1	12	8	..	" "
"	2	9	5		..	"	2	15	8	..	" "
"	3	9	6		..	"	3	15	6	..	" "
"	4	9	7		..	"	4	12	8	..	" "
"	5	9	9		..	"	5	10	6	..	" "
"	6	9	7		..	"	6	8	11	..	" "
"	6½	9	5		..	"	6½	8	2	..	" "
6th May	5½	9	9		.	6th May	5½	9	6	..	Gate closed.
"	6	9	7		..	"	6	8	2	..	" "
"	7	9	5		..	"	7	7	0	..	" "
"	8	9	3		..	"	8	5	6	..	" "
"	9	8	10		..	"	9	4	4	..	" "
"	10	8	6		..	"	10	3	4	..	" "
"	11	8	2		..	"	11	2	8	..	" "
"	12	8	0	Lowest water	..	"	12	9	6	..	" "
"	1	8	3		..	"	1	13	6	..	" "
"	2	8	5		..	"	2	15	6	..	" "
"	3	9	6		..	"	3	15	10	..	" "
"	4	9	7		..	"	4	14	8	..	" "
"	5	9	9		..	"	5	12	6	..	" "
"	6	9	10	Highest water	..	"	6	10	4	..	" "
"	6½	9	8		..	"	6½	9	8	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal.			Height above datum sill of Kyd's Dock.	Date.	Hour.	Out-side the Canal.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.					Ft.	In.		
7th May	5½	9	10	Highest water	..	7th May	5½	10	10	..	Gate closed.
"	6	9	8		..	"	6	9	6	..	" "
"	7	9	3		..	"	7	8	2	..	" "
"	8	9	1		..	"	8	6	6	..	" "
"	9	8	11		..	"	9	5	3	..	" "
"	10	8	7		..	"	10	4	3	..	" "
"	11	8	4		..	"	11	3	3	..	" "
"	12	8	2	Lowest water	..	"	12	2	6	..	" "
"	1	8	8		..	"	1	10	0	..	" "
"	2	9	2		..	"	2	12	6	..	" "
"	3	9	4		..	"	3	13	9	..	" "
"	4	9	6		..	"	4	14	6	..	" "
"	5	9	6		..	"	5	13	0	..	" "
"	6	9	7		..	"	6	10	7	..	" "
"	6½	9	8	Highest water	..	"	6½	9	11	..	" "
8th May	5½	8	10		..	8th May	5½	12	0	..	Gate closed.
"	6	9	0		..	"	6	11	0	..	" "
"	7	9	4		..	"	7	10	0	..	" "
"	8	9	6		..	"	8	7	6	..	" "
"	9	8	10		..	"	9	6	2	..	" "
"	10	8	5		..	"	10	4	9	..	" "
"	11	8	0		..	"	11	4	0	..	" "
"	12	7	7		..	"	12	3	4	..	" "
"	1	6	4	Lowest water	..	"	1	5	5	..	" "
"	2	8	3		..	"	2	11	8	..	" "
"	3	9	3		..	"	3	12	10	..	" "
"	4	9	5		..	"	4	13	7	..	" "
"	5	9	6		..	"	5	13	4	..	" "
"	6	9	6	Highest water	..	"	6	12	0	..	" "
"	6½	9	5		..	"	6½	9	10	..	" "
9th May	5½	8	9		..	9th May	5½	11	9	..	Gate closed.
"	6	9	3		..	"	6	9	8	..	" "
"	7	9	2		..	"	7	9	1	..	" "
"	8	8	9		..	"	8	8	6	..	" "
"	9	9	5		..	"	9	6	3	..	" "
"	10	8	1		..	"	10	5	2	..	" "
"	11	7	8		..	"	11	4	3	..	" "
"	12	7	3		..	"	12	3	10	..	" "
"	1	6	10	Lowest water	..	"	1	2	8	..	" "
"	2	7	8		..	"	2	7	6	..	Gate open.
"	3	10	6		..	"	3	10	0	..	" "
"	4	11	7		...	"	4	11	2	..	" "
"	5	12	0		..	"	5	11	10	..	" "
"	6	12	4	Highest water	..	"	6	12	1	..	" "
"	6½	11	1		..	"	6½	11	9	..	" "
10th May	5½	9	13		..	10th May	5½	9	6	..	Gate closed.
"	6	9	1		..	"	6	9	8	..	" "
"	7	9	4		..	"	7	9	2	..	Gate open.
"	8	8	5		..	"	8	8	3	..	" "
"	9	7	1		..	"	9	6	11	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal. Ft.	In.		Height above datum sill of Kyd's Dock.	Date.	Hour.	Out-side the Canal. Ft.	In.	Height above datum sill of Kyd's Dock.	REMARKS.
10th May	10	6	1		..	10th May.	10	5	11	..	Gate open.
"	11	5	5		..	"	11	5	0	..	" "
"	12	4	8		..	"	12	4	6	..	" "
"	1	4	1	Lowest water	..	"	1	3	10	..	" "
"	2	5	8		..	"	2	5	6	..	" "
"	3	9	2		..	"	3	9	0	..	" "
"	4	10	3		..	"	4	10	1	..	" "
"	5	11	0		..	"	5	10	10	..	" "
"	6	11	6	Highest water	..	"	6	11	4	..	" "
"	6½	11	5		..	"	6½	11	3	..	" "
11th May	5½	8	8		..	11th May	5½	9	6	..	Gate closed.
"	6	9	0		..	"	6	9	10	..	" "
"	7	8	11		..	"	7	9	9	..	" "
"	8	9	0		..	"	8	8	11	..	Gate open.
"	9	7	0		..	"	9	7	6	..	" "
"	10	6	0		..	"	10	6	3	..	" "
"	11	5	8		...	"	11	5	6	..	" "
"	12	5	0		..	"	12	5	6	..	" "
"	1	4	10		..	"	1	4	8	..	
"	2	3	9	Lowest water	..	"	2	3	5	..	Gate open.
"	3	5	6		..	"	3	5	3	..	" "
"	4	7	0		..	"	4	7	6	..	" "
"	5	9	2		..	"	5	9	0	..	" "
"	6	10	0		..	"	6	9	10	..	" "
"	6½	10	3		..	"	6½	10	1	..	" "
12th May	5½	7	16		..	12th May	5½	8	0	..	Gate closed.
"	6	7	10		..	"	6	8	8	..	" "
"	7	8	8		..	"	7	9	1	..	" "
"	8	8	8		..	"	8	9	1	..	" "
"	9	8	3		..	"	9	8	1	..	Gate open.
"	10	7	2		..	"	0	7	0	..	" "
"	11	6	2		..	"	1	6	0	..	" "
"	12	5	2		..	"	12	5	0	..	" "
"	1	4	9		..	"	11	4	7	..	" "
"	2	3	3		..	"	12	3	1	..	" "
"	3	4	6	Lowest water	..	"	3	4	5	..	" "
"	4	5	11		..	"	4	5	9	..	" "
"	5	7	10		..	"	5	7	8	..	" "
"	6	8	10		..	"	6	8	8	..	" "
"	6½	9	4		..	"	6½	9	2	..	" "
13th May	5½	5	10		..	13th May	5½	4	5	..	Gate open
"	6	6	4		..	"	6	6	0	..	Gate closed
"	7	7	6		..	"	7	7	4	..	Gate open.
"	8	8	6		..	"	8	8	4	..	" "
"	9	9	0		..	"	9	8	10	..	" "
"	10	9	3	Highest water	..	"	10	9	1	..	" "
"	11	8	10		..	"	11	8	8	..	" "
"	12	7	5		..	"	12	7	3	..	" "
"	1	6	8		..	"	1	6	5	..	" "
"	2	5	11		..t	"	2	5	6	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal. Ft.	In.		Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside the Canal. Ft.	In.	Height above datum sill of Kyd's Dock.	REMARKS.
13th May	3	5	4		..	13th May	3	5	1	..	Gate open.
,,	4	4	9		..	,,	4	4	6	..	,, ,,
,,	5	4	6	Lowest water	..	,,	5	4	2	..	,, ,,
,,	6	6	1		..	,,	6	5	11	..	,, ,,
,,	6½	7	1		..	,,	6½	6	11	..	,, ,,
14th May	5½	6	0		..	14th May	5½	3	11	..	Gate closed
,,	6	5	0		..	,,	6	3	10	..	,, ,,
,,	7	5	8		..	,,	7	5	5	..	Gat open.
,,	8	7	3		..	,,	8	7	1	..	,, ,,
,,	9	8	9		..	,,	9	8	6	..	,, ,,
,,	10	9	5		..	,,	10	9	3	..	,, ,,
,,	11	9	9	Highest water	..	,,	11	9	6	..	,, ,,
,,	12	9	8		..	,,	12	9	6	..	,, ,,
,,	1	8	3		..	,,	1	8	1	..	,, ,,
,,	2	7	2		..	,,	2	7	0	..	,, ,,
,,	3	6	3		..	,,	3	6	1	..	,, ,,
,,	4	5	4			,,	4	5	2	..	,, ,,
,,	5	4	9		..	,,	5	4	7	..	,, ,,
,,	6	4	3		..	,,	6	4	0	..	,, ,,
,,	6½	4	2		..	,,	6½	3	11	..	,, ,,
15th May	5½	7	6		..	15th May	5½	5	0	..	Gate open.
,,	6	7	2		..	,,	6	4	6	..	,, ,,
,,	7	6	10		..	,,	7	3	0	..	,, ,,
,,	8	6	5		..	,,	8	5	6	..	,, ,,
,,	9	7	8		..	,,	9	7	6	..	,, ,,
,,	10	9	0		..	,,	10	8	10	..	,, ,,
,,	11	10	0		..	,,	11	9	10	..	,, ,,
,,	12	10	7	Highest water	..	,,	12	10	5	..	,, ,,
,,	1	10	0		..	,,	1	9	10	..	,, ,,
,,	2	8	10		..	,,	2	8	5	..	,, ,,
,,	3	7	9		..	,,	3	7	7	..	,, ,,
,,	4	6	10		..	,,	4	6	8	..	,, ,,
,,	5	5	11		..	,,	5	5	9	..	,, ,,
,,	6	5	5		..	,,	6	5	3	..	,, ,,
,,	6½	5	0		..	,,	6½	4	9	..	,, ,,
16th May	5½	7	5		..	16th May	5½	4	6	..	Gate closed
,,	6	7	2		..	,,	6	4	0	..	,, ,,
,,	7	6	9		..	,,	7	3	6	..	,, ,,
,,	8	6	3		..	,,	8	3	0	..	,, ,,
,,	9	5	11	Lowest water	..	,,	9	5	9	..	,, ,,
,,	10	8	5		..	,,	10	8	3	..	,, ,,
,,	11	10	0		..	,,	11	9	10	..	,, ,,
,,	12	10	9	Highest water	..	,,	12	10	6	..	,, ,,
,,	1	10	8		..	,,	1	10	6	..	,, ,,
,,	2	9	3		..	,,	2	9	0	..	,, ,,
,,	3	8	3		..	,,	3	8	0	..	Gate open.
,,	4	6	10		..	,,	4	6	7	..	,, ,,
,,	5	5	11		..	,,	5	5	9	..	,, ,,
,,	6	5	2		..	,,	6	4	11	..	,, ,,
,,	6½	4	10		..	,,	6½	4	8	..	,, ,,

CHITPORE.

Date.	Hour.	Height of water Inside the Canal.			Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside the Canal.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.					Ft.	In.		
17th May	5½	7	11		..	17th May	5½	5	0	..	Gate closed.
"	6	7	9		..	"	6	4	6	..	" "
"	7	7	2		..	"	7	3	5	..	" "
"	8	6	10		..	"	8	3	1	..	" "
"	9	6	4	Lowest water	..	"	9	2	10	..	" "
"	10	7	2		..	"	10	7	0	..	Gate open.
"	11	9	5		..	"	11	9	3	..	" "
"	12	11	4		..	"	12	11	1	..	" "
"	1	11	9	Highest water	..	"	1	11	6	..	" "
"	2	11	5		..	"	2	11	2	..	" "
"	3	10	0		..	"	3	9	9	..	Gate closed.
"	4	8	11		..	"	4	8	0	..	" "
"	5	8	6		..	"	5	6	10	..	" "
"	6	8	1		..	"	6	5	10	..	" "
"	6½	8	0		..	"	6½	5	0	..	" "
18th May	5½	8	2		..	18th May	5½	6	4	..	Gate closed.
"	6	7	9		..	"	6	5	0	..	" "
"	7	7	6		..	"	7	4	2	..	" "
"	8	7	2		..	"	8	3	6	..	" "
"	9	6	10		..	"	9	3	0	..	" "
"	10	6	2	Lowest water	..	"	10	4	2	..	" "
"	11	8	2		..	"	11	8	0	..	Gate open.
"	12	10	9		..	"	12	10	7	..	" "
"	1	11	4		..	"	1	11	1	..	" "
"	2	12	0	Highest water	..	"	2	11	9	..	" "
"	3	11	0		..	"	3	10	9	..	Gate closed.
"	4	9	6		..	"	4	9	0	..	" "
"	5	8	10		..	"	5	7	3	..	" "
"	6	8	6		..	"	6	6	0	..	" "
"	6½	8	4		..	"	6½	5	6	..	" "
19th May	5½	8	6		..	19th May	5½	7	0	..	Gate closed.
"	6	8	3		..	"	6	6	0	..	" "
"	7	8	0		..	"	7	5	0	..	" "
"	8	7	6		..	"	8	4	0	..	" "
"	9	7	0		..	"	9	3	0	..	" "
"	10	6	7	Lowest water	..	"	10	2	3	.	" "
"	11	7	7		..	"	11	7	4	..	Gate open.
"	12	10	0		..	"	12	9	9	..	" "
"	1	11	6		..	"	1	11	3	..	" "
"	2	12	5	Highest water	..	"	2	12	2	..	" "
"	3	12	3		..	"	3	12	0	..	" "
"	4	10	0		..	"	4	9	10	..	Gate closed.
"	5	9	2		..	"	5	8	5	..	" "
"	6	8	9		..	"	6	7	0	..	" "
"	6½	8	7		..	"	6½	6	3	..	" "
20th May	5½	8	10		..	20th May	5½	8	0	..	Gate closed.
"	6	8	7		..	"	6	7	0	..	" "
"	7	8	2		..	"	7	5	9		" "
"	8	7	11		..	"	8	4	10	..	" "
"	9	7	4		..	"	9	3	8	..	" "

CHITPORE.

Date.	Hour.	Height of water Inside the Canal.			Height above datum sill of Kyd's Dock.	Date.	Hour.	Outside of the Canal.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.					Ft.	In.		
20th May	10	6	11		..	20th May,	10	2	8	..	Gate closed.
"	11	6	4	Lowest water	..	"	11	5	4	..	Gate open.
"	12	9	2		..	"	12	9	0	..	" "
"	1	11	9		..	"	1	11	6	..	" "
"	2	12	6		..	"	2	12	3	..	" "
"	3	12	10	Highest water	..	"	3	12	7	..	" "
"	4	11	8		..	"	4	11	2	..	" "
"	5	10	0		..	"	5	9	8	..	Gate closed.
"	6	9	0		..	"	6	7	10	..	" "
"	6½	8	9		..	"	6½	7	2	.	" "
21st May	5½	8	9		..	21st May	5½	8	6	..	ate open.
"	6	7	9		..	"	6	7	6	..	" "
"	7	6	3		..	"	7	6	0	..	" "
"	8	5	3		..	"	8	5	0	..	" "
"	9	4	6		..	"	9	4	4	..	" "
"	10	3	11		..	"	10	3	8	..	" "
"	11	3	5	Lowest water	..	"	11	3	2	..	" "
"	12	8	6		..	"	12	8	3	..	" "
"	1	10	8		..	"	1	10	5	..	" "
"	2	12	7		..	"	2	12	5	..	" "
"	3	13	0	Highest water	..	"	3	12	10	..	" "
"	4	12	8		..	"	4	12	5	..	" "
"	5	11	2		..	"	5	10	11	..	" "
"	6	9	7		..	"	6	9	4	..	Gate closed.
"	6½	9	2		..	"	6½	8	1	..	" "
22nd May	5½	9	2		..	22nd May	5½	9	6	..	Gate closed.
"	6	8	6		..	"	6	8	4	..	ate open.
"	7	7	2		..	"	7	7	0	..	" "
"	8	6	1		..	"	8	5	10	..	Gate open.
"	9	5	2		..	"	9	4	11	..	" "
"	10	4	5		..	"	10	4	2	..	" "
"	11	3	10		..	"	11	3	7	..	" "
"	12	3	5	Lowest water	..	"	12	3	2	..	" "
"	1	7	6		.	"	1	7	3	..	" "
"	2	11	0		..	"	2	10	10	..	" "
"	3	12	5		..	"	3	12	2	..	" "
"	4	13	0	Highest water	...	"	4	12	9	..	" "
"	5	11	6		..	"	5	11	3	..	" "
"	6	10	3		..	"	6	10	0	..	Gate closed.
"	6½	9	8		..	"	6½	8	0	..	" "

CHITPORE.

High Water inside the Canal.			Low Water inside the Canal.		
Date. 1856.	Feet.	Inches.	Date. 1856.	Feet.	Inches.
19th August	10	6	19th August	9	4
20th "	10	9	20th "	9	7
21st "	10	6	21st "	10	3
22nd "	10	6	22nd "	10	1
23rd "	10	9	23rd "	9	9
24th "	10	7	24th "	9	10
25th "	10	6	25th "	9	10
26th "	9	6	26th "	9	0
27th "	9	3	27th "	8	9
28th "	8	9	28th "	9	0
29th "	9	8	29th "	9	3
30th "	10	0	30th "	9	6
31st "	10	1	31st "	9	7
1st September	9	9	1st September	9	5
2nd "	10	0	2nd "	9	4
3rd "	9	11	3rd "	9	2
4th "	10	6	4th "	9	3
5th "	9	6	5th "	9	0
6th "	10	0	6th "	9	8
7th "	9	10	7th "	8	11
8th "	9	9	8th "	8	10
9th "	10	0	9th "	8	9
10th "	9	7	10th "	8	0
11th "	9	9	11th "	7	10
12th "	10	0	12th "	8	0
13th "	9	10	13th "	8	0
14th "	10	1	14th "	8	1
15th "	10	2	15th "	8	0
16th "	10	6	16th "	8	3
17th "	10	7	17th "	8	6
18th "	10	5	18th "	8	4
19th "	10	8	19th "	8	0
20th "	11	0	20th "	7	7
21st "	11	0	21st "	7	10
22nd "	11	6	22nd "	7	5
23rd "	12	0	23rd "	7	8
24th "	11	0	24th "	7	7
25th "	11	0	25th "	7	7
26th "	10	0	26th "	8	0
27th "	10	1	27th "	8	0
28th "	10	0	28th "	7	10
29th "	10	0	29th "	7	10
30th "	10	0	30th "	8	0
1st October	9	9	1st October	8	2
2nd "	9	7	2nd "	8	0
3rd "	10	0	3rd "	9	5
4th "	9	6	4th "	9	0

CHITPORE.

High Water inside the Canal.			Low Water inside the Canal.		
Date. 1856.	Feet.	Inches.	Date. 1856.	Feet.	Inches.
5th October	9	6	5th October	8	9
6th "	9	8	6th "	8	3
7th "	10	8	7th "	8	0
8th "	10	3	8th "	8	0
9th "	10	6	9th "	7	6
10th "	10	0	10th "	9	0
11th "	10	0	11th "	9	0
12th "	9	6	12th "	9	0
13th "	10	10	13th "	10	8
14th "	10	9	14th "	10	5
15th "	10	11	15th "	10	7
16th "	10	9	16th "	10	4
17th "	10	11	17th "	10	0
18th "	10	7	18th "	9	10
19th "	10	6	19th "	9	10
20th "	10	0	20th "	10	2
21st "	10	0	21st "	10	0
22nd "	10	0	22nd "	9	7
23rd "	9	0	23rd "	9	0
24th "	9	3	24th "	8	10

OBSERVATIONS

OF THE

TIME, RISE AND FALL OF THE TIDES,

ON THE

GAUGE OF DHAPPA DOCK,

AT THE JUNCTION OF THE

CIRCULAR CANAL

WITH THE

MAIN CHANNEL OF SALT WATER LAKE:

TAKEN DURING

Portions of the Year 1856.

THE zero of Gauge on which these readings were taken corresponds according to Mr. Clark, C. E, with 4·36 feet above datum zero of Gauge on sill of Kidderpore Old Dock.

The levels, however, taken by Mr. Frederic Burr, of the East India Railway, under the directions of the Committee, fix the zero of the above Gauge at 5.03 above the sill of Kyd's Dock, Kidderpore.

DH'APPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
April 17th					6 o'clock	4	1½		
"					7	3	4½		
"					8	2	3¼	7·34	
"	9 o'clock	2	10						Period of flood tide five hours.
"	10	3	4¾						
"	11	4	6½						
"	12	5	7						
"	1	6	5	11·45					
"					2	6	2¼		
"					3	5	7		
"					4	5	4		
"					5	4	10		
"					6	4	3		
April 18th					6 o'clock	4	9		
"					7	4	5		
"					8	3	8		
"					9	3	1		
"					10	2	7	7·61	
"	11 o'clock	3	7½						
"	12	4	8¼						
"	1	5	10¼						
"	2	6	7	11·61					
"					3	6	4¼		
"					4	5	10¼		
"					5	5	6¼		
"					6	5	2½		
April 19th					6 o'clock	5	2		
"					7	4	8½		
"					8	4	3½		
"					9	3	10½		
"					10	2	9½	7·83	
"	11 o'clock	3	10						
"	12	4	6¼						
"	1	5	3						
"	2	6	8	11·7					
"					3	6	7¼		
"					4	6	3¼		
"					5	6	0		
"					6	5	8		

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
April 20th					6 o'clock	5	8		
"					7	5	3¼		
"					8	4	10		
"					9	4	4½		
"					10	3	9	8·78	
"	11 o'clock	4	0						Period of flood tide four and half hours.
"	12	4	9½						
"	1	5	8						
"	2	6	4						
"	3	6	7	11·61					
"					4	6	4½		
"					5	6	0		
"					6	5	7½		
April 21st					6 o'clock	5	11¼		
"					7	5	6½		
"					8	5	4¼		
"					9	4	11½		
"					10	4	4		
"					11	3	11½	8·99	
"	12 o'clock	4	5						
"	1	5	3½						
"	2	6	½						
"	3	6	5½	11·63					
"					4	6	4		
"					5	6	½		
"					6	5	9½		
April 22nd					6 o'clock	6	0		Period of ebb tide six hours.
"					7	5	7½		
"					8	5	3¼		
"					9	4	11½		
"					10	4	7¼		
"					11	4	2¾		
"					12	3	9	8·78	
"	1 o'clock	4	4						
"	2	5	1½						
"	3	6	0						
"	4	6	7½						
"					5	6	5¼		
"					6	6	½		

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
April 23rd					6 o'clock	6	1		
"					7	5	8½		
"					8	5	4¼		
"					9	5	1½		
"					10	4	8½		
"					11	4	5½		
"					12	4	1¾	9·17	
"	1 o'clock	4	11						Period of flood tide five hours.
"	2	5	6½						
"	3	6	1½						
"	4	6	6½						
"	5	6	7	11·61					
"					6	6	3½		
April 24th					6 o'clock	6	3¾		Period of ebb tide seven hours.
"					7	6	2		
"					8	5	8¾		
"					9	5	4¾		
"					10	5	1		
"					11	4	9½		
"					12	4	5¾		
"					1	3	11	8·95	
"	2 o'clock	4	10½						
"	3	5	8½						
"	4	6	3¾						
"	5	6	4¾	11·42					
"					6	6	1¼		
April 25th					6 o'clock	6	3¼		Period of ebb tide seven hours.
"					7	6	0		
"					8	5	8		
"					9	5	4¾		
"					10	5	1		
"					11	4	8¼		
"					12	4	3¾		
"					1	3	11	8.95	
"	2 o'clock	4	2¾						
"	3	5	0						
"	4	5	11						
"	5	6	2½						
"	6	6	6	11·53					

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
April 26th					6 o'clock	6	3¾		Period of ebb tide eight hours.
"					7	6	0		
"					8	5	8½		
"					9	5	4		
"					10	5	0		
"					11	4	7½		
"					12	4	1½		
"					1	3	8½		
"					2	3	3½	8·33	
"	3 o'clock	4	2						
"	4	5	0						
"	5	5	11						
"	6	6*	4½	11·40					
April 27th	6 o'clock	6	4½						
"					7 o'clock	5	11		Period of ebb tide seven and a half hours.
"					8	5	5½		
"					9	4	11½		
"					10	4	3		
"					11	3	8¼		
"					12	2	11½		
"					1	2	5		
"					2	2	0	7·03	
"	3	2	8½						
"	4	3	2¾						
"	5	4	5						
"	6	5	11						
April 28th	6 o'clock	5	2½						
"	7	5	8½						
"	8	6	4¾	11·42					
"									
"					9 o'clock	5	11½		Period of ebb tide six hours.
"					10	5	4		
"					11	4	2		
"					12	3	7½		
"					1	2	8½		
"					2	2	1½	7·15	
"	3	2	11½						
"	4	4	1½						
"	5	4	5						
"	6	5	11½						

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
April 29th	6 o'clock	5	0						
,,	7	5	8½						
,,	8	6	4½	11·40					
,,					9 o'clock	5	11½		Period of ebb tide six and a half hours.
,,					10	5	4½		
,,					11	4	6¾		
,,					12	3	9¾		
,,					1	2	7½		
,,					2	3	2½		
,,					3	1	10¼	6.88	
,,	4	2	3½						
,,	5	3	7½						
,,	6	4	2½						
April 30th					6 o'clock	2	2½	7·23	
,,	7 o'clock	2	11½						Period of flood tide five hours.
,,	8	3	9¾						
,,	9	4	10¾						
,,	10	5	11¼						
,,	11	6	3½	11·33					
,,					12	6	¼		
,,					1	5	8½		
,,					2	5	4¼		
,,					3	4	11¼		
,,					4	4	1¼		
,,					5	3	7¼		
,,					6	3	½		
May 1st					6 o'clock	2	3½		
,,					7	1	9¾	6·84	
,,	8 o'clock	2	10						
,,	9	3	11½						
,,	10	5	3¾						
,,	11	6	3¼						
,,	12	6	8¼	11·73					
,,									
,,					1	6	2¾		
,,					2	5	9½		
,,					3	5	3½		
,,					4	4	8½		
,,					5	4	1½		
					6	3	10¼		

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
May 2nd					6 o'clock	5	2¼		
"					7	4	7½		
"					8	2	5½	7·49	
"	9 o'clock	5	4¾						Period of flood tide four hours.
"	10	5	11						
"	11	6	3						
"	12	6	8¼						
"					1	6	3½		
"					2	5	10½		
"					3	5	1½		
"					4	4	8¼		
"					5	4	2¼		
"					6	3	11		
May 3rd					6 o'clock	5	7		
"					7	5	2¼		
"					8	4	10		
"					9	3	4½	8·39	
"	10 o'clock	4	1½						Period of flood tide four hours.
"	11	5	7¼						
"	12	6	1½						
"	1	6	3½						
"					2	6	½		
"					3	5	9½		
"					4	5	3½		
"					5	4	1¼		
"					6	4	9¼		
May 4th					6 o'clock	5	9½		
"					7	5	4½		
"					8	4	10½		
"					9	3	4½		
"					10	3	2	8·23	
"	11 o'clock	5	8½						Period of flood tide four hours.
"	12	6	5¼						
"	1	6	8½						
"	2	6	10½	11.90					
"									
"					3	6	7½		
"					4	6	4½		
"					5	6	3½		
"					6	6	1¼		

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
May 5th	6 o'clock	6	8½		7 o'clock	6	5½		
"					8	6	1½		
"					9	5	11¼		
"					10	5	1¾		
"					11	4	9¼	9·8	
"									
"	12	4	11						Period of
"	1	5	3¼						flood tide
"	2	5	11¼						four hours.
"	3	6	7						
"	4	6	9½	11·83					
"					5	6	7¼		
"					6	6	4½		
May 6th	6 o'clock	6	8¾	11·70					
"					7 o'clock	6	6½		Period of
"					8	6	1¼		ebb tide
"					9	5	8¼		six hours.
"					10	5	1½		
"					11	4	6½		
"					12	4	2½	9·23	
"	1	4	11½						
"	2	5	3¼						
"	3	6	1¼						
"	4	6	4¾						
"	5	6	7½						
"					6	6	0		
May 7th	6 o'clock	6	8¼						
"	7	6	11¼	11·97					
"					8 o'clock	5	9¼		Period of
"					9	5	1		ebb tide
"					10	4	2½		six hours.
"					11	3	10½		
"					12	3	9¼		
"					1	3	7	8·61	
"	2	5	3½						
"	3	4	4¾						
"	4	6	5½						
"	5	6	7¼						
"	6	6	9¼						

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
May 8th	6 o'clock	6	5¾						
,,	7	6	3						
,,					8 o'clock	5	9½		
,,					9	5	2		
,,					10	4	2¼		
,,					11	4	0		
,,					12	3	3¼		
,,					1	3	0	8·03	
,,	2	4	2¾						
,,	3	4	10½						
,,	4	5	9½						
,,	5	6	3¼						
,,	6	6	7½	11·65					
May 9th	6 o'clock	6	3						
,,	7	6	4½						
,,	8	6	6½	11·57					
,,					9 o'clock	5	1¼		
,,					10	4	10¼		
,,					11	4	0		
,,					12	3	2¼		
,,					1	3	9		
,,					2	2	11	7·94	
,,	3	3	10¼						
,,	4	4	9¾						
,,	5	5	6¼						
,,	6	6	0						
May 10th	6 o'clock	6	0½						
,,	7	6	3						
,,	8	6	6	11·53					
,,					9 o'clock	5	9¾		
,,					10	4	10		
,,					11	4	0		
,,					12	3	5¼		
,,					1	2	2¼		
,,					2	2	0	7.03	
,,	3	3	1½						
,,	4	3	11						
,,	5	4	9½						
,,	6	5	7½						

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
May 11th	6 o'clock	6	0						
,,	7	6	4						
,,	8	6	7½	11.65					
,,					9 o'clock	5	11		Period of
,,					10	5	4¼		ebb seven
,,					11	4	10		hours.
,,					12	4	5¼		
,,					1	4	0		
,,					2	3	7		
,,					3	2	6½	7.57	
,,	4	3	3						
,,	5	3	9						
,,	6	4	7½						
May 12th	6 o'clock	4	9						
,,	7	5	6¼						
,,	8	6	4½						
,,	9	6	5½	11 49					
,,					10 o'clocl	5	3½		
,,					11	4	7¼		
,,					12	3	9¼		
,,					1	3	3¼	7.38	
,,					2	2	8		
,,					3	2	4¼		
,,	4	3	3¼						
,,	5	4	3¾						
,,	6	5	1½						
May 13th	6 o'clock	3	8						
,,	7	4	0						
,,	8	4	7¾						
,,	9	5	3½						
,,	10	6	1½	11 15					
,,					11 o'clock	5	9½		Period of
,,					12	5	3½		ebb seven
,,					1	4	10		hours.
,,					2	4	0		
,,					3	3	3½		
,,					4	2	7½		
,,					5	2	0	7	
,,	6 o'clock	3	0						

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta. Ft.	In.	Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake. Ft.	In.	Height above datum sill of Kyd's Dock.	REMARKS.
May 14th	6 o'clock	3	5½						
"	7	4	0						
"	8	4	11						
"	9	5	5½						
"	10	6	0						
"	11	6	3½	11.33					
"					12 o'clock	6	0		Period of
"					1	5	8½		ebb seven
"					2	5	2¾		hours.
"					3	4	9½		
"					4	4	0		
"					5	3	4		
"					6	2	4½	7.40	
May 15th	6 o'clock	3	1¼						Period of
"	7	3	10½						flood six
"	8	4	9¼						hours.
"	9	5	4½						
"	10	5	10¼						
"	11	6	3						
"	12	6	5¾	11.51					
"					1 o'clock	6	3½		
"					2	6	0		
"					3	5	6½		
"					4	4	11¼		
"					5	4	3½		
"					6	3	10	8.86	
May 16th					6 o'clock	2	3¼	7.30	
"	7 o'clocl	3	2½						Period of
"	8	4	0						flood seven
"	9	4	11¼						hours.
"	10	5	8¼						
"	11	6	1						
"	12	6	6¼						
"	1	6	7½	11.65					
"					2	6	½		
"					3	5	9½		
"					4	5	1		
"					5	4	10½		
"					6	4	3¼		

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta. Ft.	In.	Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake. Ft.	In.	Height above datum sill of Kyd's Dock.	REMARKS.
May 17th					6 o'clock	3	0½		
,,					7	2	5½	7.49	
,,	8 o'clock	3	1½						Period of flood seven hours.
,,	9	3	10						
,,	10	4	6½						
,,	11	5	3½						
,,	12	5	9½						
,,	1	6	2½						
,,	2	6	6	11.53					
,,					3	6	0		
,,					4	5	6¾		
,,					5	4	11		
,,					6	4	1¼		
May 18th					6 o'clock	4	3½		
,,					7	3	10		
,,					8	2	7	7.61	
,,	9 o'clock	3	1½						
,,	10	3	10						
,,	11	4	11						
,,	12	5	6						
,,	1	5	10						
,,	2	6	6¾	11.59					
,,					3	5	10		
,,					4	5	2½		
,,					5	4	8		
,,					6	4	0		
May 19th					6 o'clock	4	8		
,,					7	4	3		
,,					8	3	6		
,,					9	2	7½	7.65	
,,	10 o'clock	3	1½						Period of flood six hours.
,,	11	3	8						
,,	12	4	6						
,,	1	5	2						
,,	2	5	9¼						
,,	3	6	6½	11.57					
,,					4	5	10		
,,					5	5	2		
,,					6	4	9½		

DHAPPA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
May 20th					6 o'clock	4	0		
"					7	3	8		
"					8	3	5		
"					9	2	10		
"					10	2	2½	7.23	
"	11 o'clock	2	9						
"	12	3	7½						
"	1	4	6						
"	2	5	8						
"	3	6	2						
"	4	6	5	11.45					
"					5	5	9		
"					6	5	4¼		

DHAPPA.

Date.	High Water.		Low Water.		Remarks.
	Feet.	Inches.	Feet.	Inches.	
17th July 1856 ..	7	6½	6	3½	
18th ditto ..	7	6¾	6	3	
19th ditto ..	7	6	6	2½	
20th ditto ..	7	5¼	6	2	
21st ditto ..	6	10¼	6	1½	
22nd ditto ..	6	10½	6	1¼	
23rd ditto ..	6	10¼	5	6½	
24th ditto .	6	8½	5	6	
25th ditto ..	7	1	6	8½	
26th ditto ..	7	6½	6	9	
27th ditto ..	7	6	6	8	
28th ditto ..	7	3	6	3	
29th ditto ..	7	0	5	9¾	
30th ditto ..	7	3	6	3	
31st ditto ..	7	3	6	2	
1st August 1856 ..	7	3½	6	1¾	
2nd ditto ...	7	3	6	3½	
3rd ditto ..	7	3	6	2½	
4th ditto .	7	4	6	4	
5th ditto ..	7	6	6	9	
6th ditto ..	7	6½	6	6½	
7th ditto ..	7	1	6	6¼	
8th ditto ..	6	4	6	4	
9th ditto ..	6	2½	6	3½	
10th ditto ..	6	4¼	6	3¼	
11th ditto ..	6	3	5	3¾	
12th ditto ..	6	2	5	1½	
13th ditto ..	5	9¼	4	9¼	
14th ditto ..	5	7½	4	11¾	
15th ditto ..	6	9	5	6¾	
16th ditto ..	7	6½	6	3	
17th ditto ..	7	5¾	5	10½	
18th ditto ..	7	6¼	6	4¾	
19th ditto ..	8	8¼	6	9¼	13·72 feet above datum highest water mark Rains.
20th ditto ..	7	8¾	6	10¾	
21st ditto ..	7	9¼	7	3	
22nd ditto ..	7	6	6	9½	
23rd ditto ..	7	3½	6	4¼	
24th ditto ..	6	9½	6	3	
25th ditto ..	6	2½	5	10¼	
26th ditto ..	7	6	6	9	
27th ditto ..	7	6½	6	10	
28th ditto ..	7	8½	6	10½	
29th ditto ..	7	10¼	6	9	
30th ditto ..	6	9	5	10¼	
31st ditto ..	6	8¾	5	9	
1st September 1856 .	6	6	5	6½	
2nd ditto ..	6	3½	5	4	
3rd ditto ..	6	10	5	8½	
4th ditto ..	7	3	6	4½	

DHAPPA.

Date.	High Water.		Low Water.		Remarks.
	Feet.	Inches.	Feet.	Inches.	
5th September 1856 .	7	6	6	6½	
6th ditto ..	7	8½	6	6	
7th ditto ..	7	6	6	5½	
8th ditto ..	7	2½	6	1	
9th ditto ..	6	9	5	9	
10th ditto ..	6	6	5	3	
11th ditto ..	6	9	5	4¼	
12th ditto ..	7	3	5	6½	
13th ditto ..	7	4	5	11	
14th ditto ..	7	3	6	4	
15th ditto ..	7	6	7	0	
16th ditto ..	7	8	7	2	
17th ditto ..	7	8	7	2	
18th ditto ..	7	9	7	6	
19th ditto .	7	8½	7	7½	
20th ditto ..	7	7	7	3	
21st ditto ..	7	5	7	0	
22nd ditto ..	7	2	6	0	
23rd ditto ..	6	9	4	6	
24th ditto ..	6	3½	4	2	
25th ditto .	6	4	4	2½	
26th ditto ..	6	6	4	4¾	
27th ditto ..	6	9	4	9	
28th ditto ..	6	10	4	11	
29th ditto ..	6	11	5	1	
30th ditto ..	7	1	6	0	
1st October 1856 ..	7	4	6	10½	
2nd ditto ..	7	2	6	9	
3rd ditto ..	7	6	5	11	
4th ditto ..	0	0	0	0	
5th ditto ..	6	11	5	6	
6th ditto ..	6	9	5	3	
7th ditto ..	6	6	5	0	
8th ditto ..	6	3	4	10	
9th ditto ..	6	0	5	2	
10th ditto ..	5	10	4	2	
11th ditto ..	6	6	5	10	9·2 feet above datum lowest water mark Ruins.
12th ditto ..	6	10	6	9	
13th ditto ..	7	11	7	6	
14th ditto ..	8	0	7	7	
15th ditto .	8	3	7	9	
16th ditto ..	8	2½	7	8½	
17th ditto ..	8	2	7	6	
18th ditto ..	8	0	7	4	
19th ditto ..	7	9	7	1	
20th ditto ..	7	6	6	11	
21st ditto ..	7	4	5	6	
22nd ditto ..	6	0	4	9	
23rd ditto ..	5	9	4	6	
24th ditto ..	5	7	4	9	

OBSERVATIONS

OF THE

TIME, RISE AND FALL OF THE TIDES,

ON THE

GAUGE AT BAMUNGHATTA,

5 MILES DOWN THE COURSE

OF THE

MAIN CHANNEL OF THE SALT WATER LAKE

TAKEN DURING

Portions of the Year 1856.

NOTE.—These readings were taken on a Pile driven for the purpose to which no levels have been taken ; they therefore show the total Rise on any given day only.

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water-Lake.		Height above datum sill of Kyd's Dock.	R Remarks.
		Ft.	In.			Ft.	In.		
April 17th					6 o'clock	2	6¾		
"					7	1	3¼		
"					8		1½		
"	9 o'clock	2	9¼						
"	10	5	1						
"	11	7	½						
"	12	7	9¾						
"					1	7	6¾		Tide ebb-
"					2	7	3½		ed one hour
"					3	6	0		earlier than
"					4	5	3¼		at Dhappa.
"					5	4	3¼		
"					6	3	1		
April 18th					6 o'clock	3	6¼		
"					7	2	3½		
"					8	1	4¼		
"	9 o'clock	1	7½						
"	10	3	10¾						
"	11	6	6½						
"	12	7	9½						
"	1	8							
"					2	7	9½		Tide ebb-
"					3	6	9½		ed one hour
"					4	6	1¼		earlier than
"					5	5	4½		at Dhappa.
"					6	4	4¼		
April 19th					6 o'clock	4	4½		
"					7	3	4¾		
"					8	2	5		
"					9	1	4¼		
"	10 o'clock	3	4¾						
"	11	6	2½						
"	12	7	8¾						
"	1	8	½						
"					2	7	11¼		Tide ebb-
"					3	7	7¾		ed one hour
"					4	6	8½		earlier than
"					5	6	1¼		at Dhappa.
"					6	5	4¾		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
April 20th					6 o'clock	5	1¾		
"					7	4	4¼		
"					8	3	6¾		
"					9	2	5½		
"					10	1	10½		
"	11 o'clock	5	1¾						Tide rose at same time but ebbed one hour earlier than at Dhappa.
"	12	7	7¼						
"	1	8	0						
"	2	8	1½						
"					3	7	11¼		
"					4	7	5¾		
"					5	6	6½		
"					6	5	10¾		
April 21st					6 o'clock	5	10¾		
"					7	5	1¾		
"					8	4	3½		
"					9	3	5½		
"					10	2	9¼		
"	11 o'clock	4	9¼						
"	12	6	9½						
"	1	7	10¾						
"	2	8	3½						
"					3	8	1¾		
"					4	7	11½		
"					5	7	1¾		
"					6	6	5½		
April 22nd					6 o'clock	6	3¼		
"					7	5	8½		
"					8	4	11¼		
"					9	3	11½		
"					10	3	1¾		
"	11 o'clock	3	3¾						Period of flood tide four hours.
"	12	6	3¼						
"	1	7	9½						
"	2	8	1¼						
"	3	8	3						
"					4	7	11½		
"					5	7	7¾		
"					6	6	8¾		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
April 23rd					6 o'clock	6	6¾		
,,					7	5	10¾		
,,					8	5	1½		
,,					9	4	5¼		
,,					10	3	4¾		
,,					11	2	9¼		
,,	12 o'clock	4	9¾						Period of flood tide five hours.
,,	1	7	½						
,,	2	7	11½						
,,	3	8	1¼						
,,	4	8	3¾						
,,					5	7	8¾		
,,					6	7	3¼		
April 24th					6 o'clock	6	9½		
,,					7	6	1¾		
,,					8	5	5½		
,,					9	4	6¾		
,,					10	3	10		
,,					11	1	11¼		
,,	12 o'clock	3	1¼						Difference between high and low water 6 feet 3¼ inches.
,,	1	6	0						
,,	2	7	9¾						
,,	3	8	1						
,,	4	8	2½						
,,					5	7	11¼		
,,					6	7	7¾		
April 25th					6 o'clock	6	7½		Period of ebb tide seven hours.
,,					7	6	1¼		
,,					8	5	5½		
,,					9	4	7¾		
,,					10	3	8¼		
,,					11	2	9¾		
,,					12	2	1¾		
,,	1 o'clock	4	6¾						
,,	2	6	3½						
,,	3	7	9¼						
,,	4	7	11¼						
,,	5	8	0						
,,					6	7	6¼		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
April 26th					6 o'clock	6	11½		
"					7	6	1¼		
"					8	5	5⅙		
"					9	4	5¾		
"					10	3	6¼		
"					11	2	7		
"					12	1	10½		
"	1 o'clock	2	11¼						
"	2	4	10¾						
"	3	6	11¾						
"	4	8	¼						
"	5	8	2½						
					6	7	11½		
April 27th					6 o'clock	6	6¼		Period of ebb tide eight hours.
"					7	5	7¼		
"					8	4	8¾		
"					9	4	1¼		
"					10	3	2½		
"					11	2	1¼		
"					12	0	10¼		
"					1	0	1¾		
"	2 o'clock	2	9¼						Difference between high and low water 7 feet 7 inches.
"	3	5	1¼						
"	4	6	6¾						
"	5	7	3¾						
"	6	7	8¾						
April 28th	6 o'clock	6	11½						
"	7	7	1½						
"					8 o'clock	6	2¾		Period of ebb tyle seven hours.
"					9	5	4¾		
"					10	4	5⅙		
"					11	3	4¾		
"					12	2	4½		
"					1	1	0½		
"					2	0	6¾		
"	3	2	5¾						Difference between high and low water 6 feet 3 inches.
"	4	4	5¼						
"	5	5	9¼						
"	6	6	9¾						

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
April 29th	6 o'clock	5	4¾						
"	7	6	3½						
"	8	6	10¾						
"	9	7	1½						
"					10 o'clock	6	6½		Period of ebb tide seven hours.
"					11	5	6¾		
"					12	4	7½		
"					1	3	9		
"					2	2	6¾		
"					3	1	5¼		
"					4	0	2¾		
"	5	1	9¾						
"	6	3	1¼						
April 30th	6 o'clock	1	6¾						
"	7	3	6¼						
"	8	5	5½						
"	9	6	8¾						Tide rose one hour earlier than at Dhappa.
"	10	7	4¼						
"	11	7	6						
"					12 o'clock	7	0½		
"					1	6	1¼		
"					2	5	3¾		
"					3	4	4¾		
"					4	3	4¾		
"					5	2	3¼		
"					6	1	1¾		
May 1st					6 o'clock	2	9¾		
"					7	1	9¼		
"	8 o'clock	3	3¼						Difference between high and low water 6 feet 3½ inches.
"	9	5	3						
"	10	7	1½						
"	11	7	10¾						
"	12	8	0¾						
"					1	7	8½		
"					2	6	10¾		
"					3	6	1½		
"					4	5	8¾		
"					5	4	9¼		
"					6	3	9½		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
May 2nd					6 o'clock	3	11½		
"					7	3	2½		
"					8	2	4¾		Period of flood tide four and a half hours.
"	9 o'clock	3	5½						
"	10	5	8¾						
"	11	7	5¾						
"	12	7	10¾						
"	1	8	0¼						
"					2	7	8½		
"					3	7	2½		
"					4	6	5¼		
"					5	5	9		
"					6	5	1¼		
May 3rd					6 o'clock	5	0¾		
"					7	4	5¼		
"					8	3	7¾		
"					9	2	10¼		
"	10 o'clock	4	8¼						
"	11	7	1½						
"	12	8	0						
"	1	8	1¾						
"	2	8	3¼						
"					3	8	1		Tide ebbed one hour later than at Dhappa.
"					4	7	9¾		
"					5	6	10½		
"					6	6	5¼		
May 4th					6 o'clock	6	5¼		
"					7	5	8½		
"					8	4	7¾		
"					9	4	0		
"					10	3	5½		
"	11 o'clock	6	0						
"	12	7	10½						
"	1	8	1½						
"	2	8	2¼						
"	3	8	3¼						
"					4	8	1½		
"					5	7	1¾		
"					6	6	7¾		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks
		Ft.	In.			Ft.	In.		
May 5th					6 o'clock	6	11½		
"					7	6	3¼		
"					8	5	3¾		
"					9	4	3¾		
"					10	3	6¾		
"	11 o'clock	5	7½						Period of flood tide five hours.
"	12	7	6¼						
"	1	8	2½						
"	2	8	3¼						
"	3	8	5½						
"					4	8	2½		
"					5	7	9¼		
"					6	6	9		
May 6th					6 o'clock	7	½		
"					7	6	1¾		
"					8	5	2½		
"					9	4	4¼		
"					10	3	7¾		
"					11	2	9¼		
"	12 o'clock	5	1½						
"	1	7	8¼						
"	2	8	1¾						
"	3	8	3¼						
"	4	8	4¼						
"					5	8	1¼		
"					6	7	7½		
May 7th					6 o'clock	6	10¼		
"					7	6	4		
"					8	5	10¼		
"					9	5	0½		
"					10	4	2¾		
"					11	3	7¼		
"	12 o'clock	5	½						Period of flood tide five hours.
"	1	7	4½						
"	2	7	10¾						
"	3	8	1¼						
"	4	8	2¼						
"					5	[illegible]	11½		
"					6	7	2½		
"					6	6	6		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
May 8th					7 o'clock	6	0¾		
"					8	5	3½		
"					9	4	5¾		
"					10	3	6¼		
"					11	2	11½		
"					12	2	1¾		
"	1 o'clock	4	10½						
"	2	6	10¾						
"	3	6	4½						
"	4	7	9¾						
"	5	7	11½						
"					6	7	5¾		
"									
May 9th					6 o'clock	6	3¾		
"					7	5	8		
"					8	4	9¼		
"					9	4	2		
"					10	3	3¼		
"					11	2	8½		
"					12	2	2¾		
"	1 o'clock	5	1¼						
"	2	6	10½						
"	3	7	8¾						
"	4	7	10¾						
"	5	7	11½						
"					6	7	5¼		
May 10th					6 o'clock	6	11½		
"					7	6	1		Period of ebb tide seven hours.
"					8	5	2½		
"					9	4	4¾		
"					10	3	4¼		
"					11	2	7¼		
"					12	2	1¼		
"					1	1	9½		
"	2 o'clock	3	8½						
"	3	5	11½						
"	4	7	2½						
"	5	7	8½						
"	6	7	10¾						

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
May 11th					6 o'clock	7			
"					7	6	2¾		
"					8	6	4¼		Difference
"					9	4	6¾		between
"					10	3	7¾		high and
"					11	2	8		low water
"					12	1	8½		mark 6 feet
"					1	1	1¾		2½ inches.
"	2 o'clock	2	11½						
"	3	4	7¼						
"	4	5	11½						
"	5	7	2¾						
"	6	7	4½						
May 12th	6 o'clock	6	7¾						
"					7 o'clock	6	5½		
"					8	5	8¾		Period of
"					9	4	11¼		ebb tide
"					10	4	1½		seven and
"					11	3	1¼		half hours.
"					12	2	1		
"					1	1	4¾		
"					2	1	0½		
"	3	2	6½						
"	4	4	5¼						
"	5	5	5¾						
"	6	6	5½						
May 13th	6 o'clock	5	9¼						
"	7	6	5¼						
"	8	6	9¼						
"	9	6	11½						
"					10 o'clock	5	10½		
"					11	4	3¼		
"					12	3	11¼		
"					1	2	10¾		
"					2	1	½		
"	3	2	4¼						
"	4	4	2¼						
"	5	5	3¾						
"	6	5	11½						

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
May 14th	6 o'clock	3	3¼						
,,	7	4	11¾						
,,	8	6	4½						
,,	9	6	11¼						
,,	10	7	5¼						
,,					11 o'clock	6	9½		
,,					12	6			
,,					1	5	1¾		
,,					2	4	3½		
,,					3	3	3½		
,,					4	1	9½		
,,	5	2	1¼						
,,	6	3	9						
May 15th					6 o'clock	1	9½		Difference between high and low water mark 5 feet 11 inches.
,,	7 o'clock	3	2½						
,,	8	5	6½						
,,	9	6	8¾						
,,	10	7	6						
,,	11	7	8½						
,,					12	7	5½		
,,					1	6	6½		
,,					2	5	9¼		
,,					3	5	1¾		
,,					4	4	6		
,,					5	3	7½		
,,					6	2	8½		
May 16th					6 o'clock	2	6¾		
,,					7	1	5¾		
,,	8 o'clock	3	10¾						Period of flood tide five hours.
,,	9	5	9½						
,,	10	7	2¾						
,,	11	7	9¼						
,,	12	7	11¼						
,,					1	7	6¾		
,,					2	6	6¼		
,,					3	5	11		
,,					4	4	9¾		
,,					5	3	11½		
,,					6	3	2½		

BAMUNGHATTA.

Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	REMARKS.
		Ft.	In.			Ft.	In.		
May 17th					6 o'clock	2	4½		
,,					7	1	6¾		
,,	8 o'clock	4	7½						
,,	9	6	8¾						
,,	10	7	8½						
,,	11	7	10½						
,,	12	7	11½						
,,					1	7	5¼		
,,					2	6	7¾		
,,					3	5	9½		
,,					4	4	11¾		
,,					5	3	10¼		
,,					6	2	10¾		
May 18th					6 o'clock	3	4½		
,,					7	2	6½		Difference between high and low water mark 6 feet 5½ inches.
,,					8	1	7¾		
,,	9 o'clock	3	6¼						
,,	10	6	4½						
,,	11	7	3¾						
,,	12	7	11½						
,,	1	8	1½						
,,					2	7	10½		
,,					3	6	9¼		
,,					4	5	10		
,,					5	4	11¼		
,,					6	3	11¾		
May 19th					6 o'clock	4	6¼		
,,					7	3	5½		
,,					8	2	2¾		
	9 o'clock	2	9½						Period of flood tide about four and a half hours.
,,	10	5	0½						
,,	11	7	5½						
,,	12	7	9½						
,,	1	8	2¾						
,,					2	7	9½		
,,					3	7	3½		
,,					4	6	5		
,,					5	5	10¼		
,,					6	5	1½		

BAMUNGHATTA.

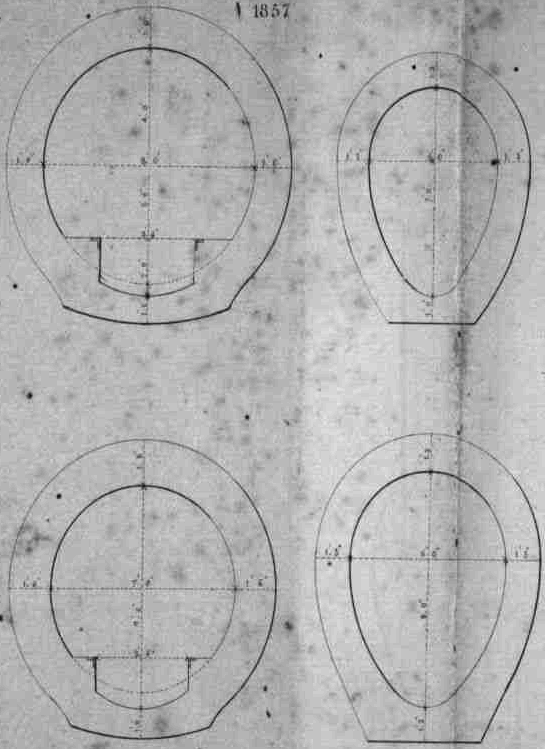
Date.	Time.	Flood. Running towards Calcutta.		Height above datum sill of Kyd's Dock.	Time.	Ebb. Running towards Salt Water Lake.		Height above datum sill of Kyd's Dock.	Remarks.
		Ft.	In.			Ft.	In.		
May 20th					6 o'clock	4	9¼		
"					7	3	10		
"					8	2	10½		
"					9	1	11¼		
"	10 o'clock	4	2½						
"	11	6	11¼						
"	12	7	8¾						
"	1	8	1½						
"	2	8	3¼						
"					3	7	9½		
"					4	7	0½		
"					5	6	2¾		
"					6	5	6½		

The rapid rise of the tide from low water mark during the first two hours of the flood is remarkable.

Calcutta Drainage Committee
Cross Sections of proposed Sewers

No. 1

A 1857



Scale 1 Inch = 7 Feet

Drawn by Capt. Fulton & Lieut. Hall, R.E. & Mr. Bruce, Supt. Calcutta Drainage Committee

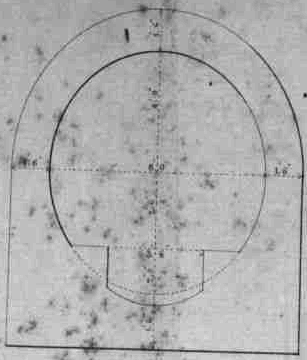
Calcutta Drainage Committee

Cross Section of Sewers

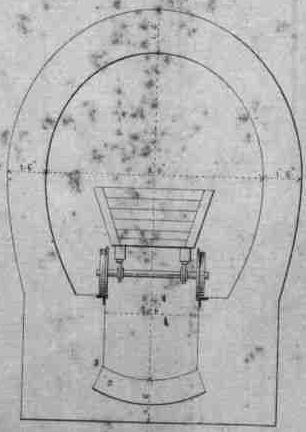
proposed for bad Soil

1837

№ 11



Scale 1 inch = 1 foot



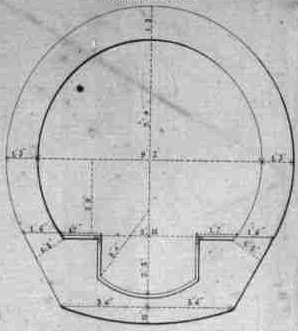
In transfer paper by Allied Kodak Ltd., by H.M. Smith, Serv. Sect. Hist. of Rly 2007

Calcutta Drainage Committee

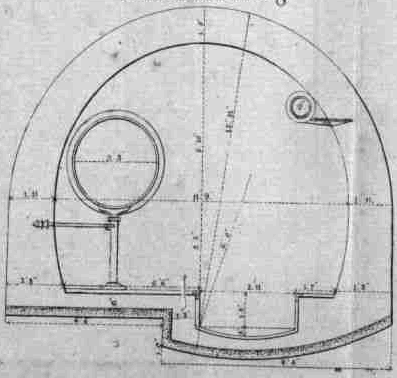
Form of Sewers Constructed in Paris

No. III

Rue des Ecoles



Boulevart de Strasbourg



Scale of 100 Metres

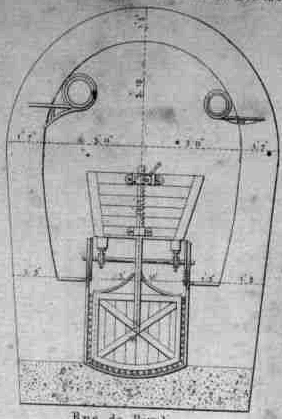
Scale of 10 Feet

Drawn from a paper by Mahomed Aroon Esqr. by E.W. Smith Surv. Genl's Office Cal. May 1862.

Calcutta Drainage Committee

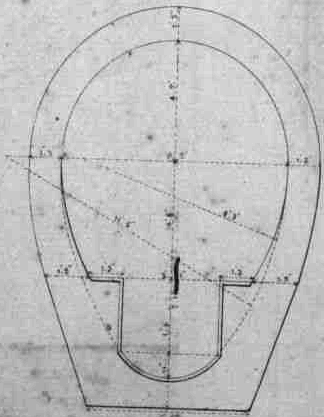
Form of Sewers Constructed in Paris.

Nº IV



Rue de Rivoli

1857.



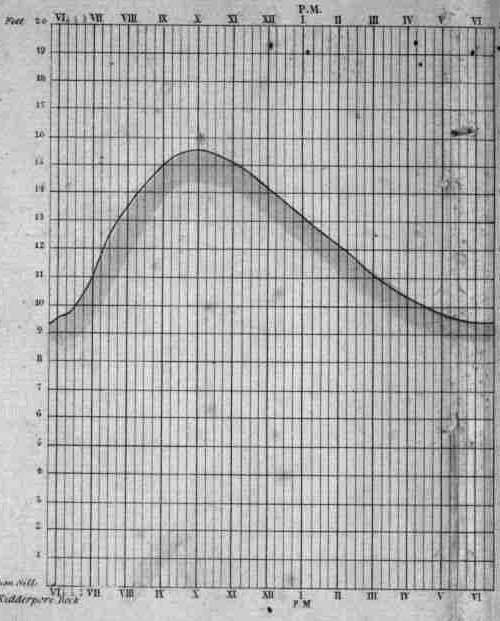
Quai de la Conference (projet)

No. VIII

DIAGRAM

Shewing the rise & fall of the Tide in the River Hooghly taken on the 12th of August 1826

Neap Tides Moon's age 11 days.

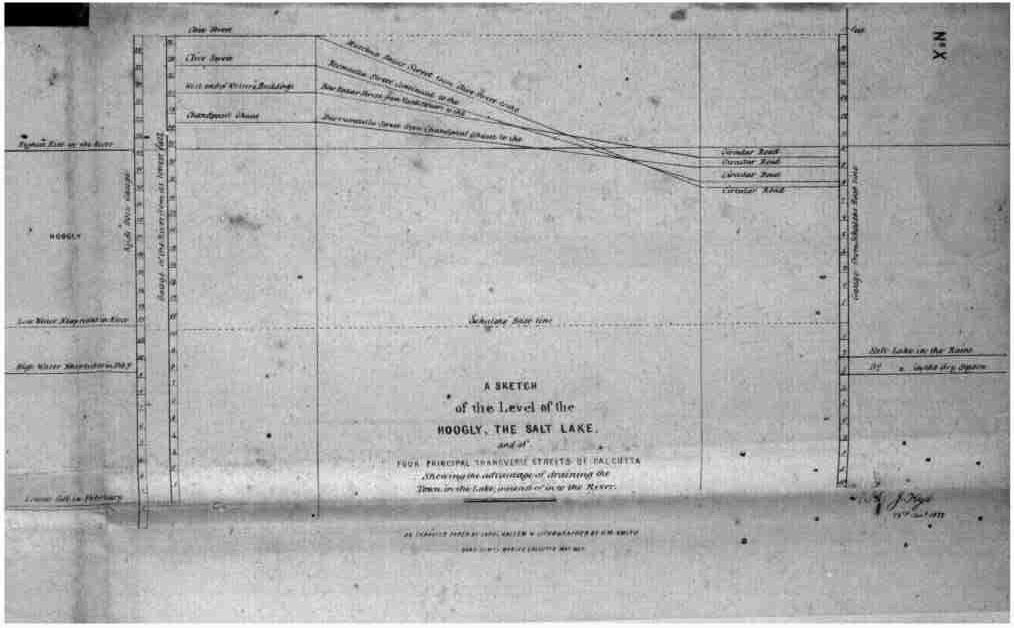


Note. *The blue wash shews the rise & fall of the Tide taken from actual observations at intervals of 15 minutes*

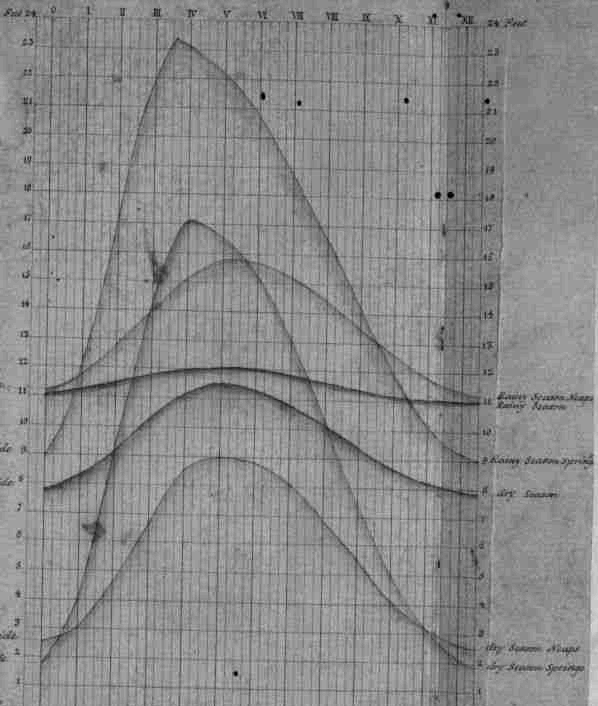
The vertical lines denote the hours & quarters of hours

The horizontal lines denote the rise of the Tide in Feet

[illegible] PRINTED BY [illegible] & CO. [illegible]


N.N.
Clive Street
Clive Street
Wellesley Street Street from Clive Street Circle
Wellesley Street continued to the
New Street Street from Wellesley to Old
Chowringhee Street
Chowringhee Street from Chowringhee Chauk to the
Circular Road
Circular Road
Circular Road
Circular Road
Highest Rise in the River
HOOGLY
Low Water Mark point in River
High Water Mark point in Ditto
Lowest fall in February
Hoogly at the Bore rise in Neap tide
Hoogly at the Bore rise in Spring tide
Hoogly Permanent Bank line
Salt Lake in the Rains
Salt Lake dry Approx
Scholing Base line
A SKETCH
of the Level of the
HOOGLY, THE SALT LAKE,
and of
FOUR PRINCIPAL TRANSVERSE STREETS OF CALCUTTA
Shewing the advantage of draining the
Town in the Lake, instead of in to the River.
AS CHARGED PAPER BY CAPT. SMITH & COPY PRINTED BY H.M. SMITH
SURVEYOR GENERAL OF CALCUTTA 1847 1851

Shewing the Relative height of the River Hooghly and Salt Water Lake Tides



The vertical lines denote the hours & quarters of hours

The horizontal lines denote the rise of the Tide in Feet